An evaluation of the role of performance feedback to improve the practice of tracheal suctioning amongst health care professionals

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An evaluation of individualised performance feedback on nurses' and physiotherapists' tracheal suctioning practices

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ABSTRACT

There is evidence from the literature that one-off educational interventions result in only short-term improvements in knowledge and skills and may do little to ensure that knowledge is enacted in practice. This study was designed to evaluate the role of individualised performance feedback as a mechanism for improving knowledge and skills retention using tracheal suctioning as a case study. Tracheal suctioning is a frequently performed procedure that has several associated risks and complications. These pose not only additional risks to the critically ill patient, but also considerable financial cost to the National Health Service (NHS).

The study was a two-centre individual randomised controlled trial comparing the effect of standard ward based education with standard education followed by individualised performance feedback. The outcomes were knowledge and performance of tracheal suctioning and the association between knowledge and practice. The study took place in two large inner London NHS Trusts. The sample size was 95 and consisted of registered nurses and chartered physiotherapists. At initial baseline level, a standardised educational intervention about tracheal suctioning was developed for both an intervention and control group, based around current best evidence. Participants were subsequently observed in practice and completed a knowledge-based questionnaire. On one of the sites, practice was observed in the clinical setting; on the other site the observations took place using simulation. The interventional arm subsequently received performance feedback. Observational and questionnaire data were collected again four months after initial teaching. For both groups in both settings, knowledge improved after initial teaching, and there was a moderate correlation between knowledge and practice. However, the performance feedback had a greater effect on practice than knowledge, which resulted in a weaker correspondence between knowledge and practice post intervention, which was an unexpected finding. The findings of this study demonstrate the effectiveness of the intervention, and show performance feedback as a powerful strategy for improving practice. It is recognised that if practitioners are not regularly exposed to certain skills it is difficult to refine and perfect these techniques. It is recommended that this framework be used for future research to promote evidence-based practice and competence in complex clinical skills.

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

There is evidence from the literature that one-off educational interventions result in only short-term improvements in knowledge and skills and do little to ensure that knowledge is enacted in practice. This study was designed to evaluate individualised performance feedback as a mechanism for improving knowledge and skills retention over time using tracheal suctioning as a case study. Tracheal suctioning is a frequently performed procedure with many associated risks and complications. These range from hypoxaemia (Adlkofer and Powaser 1978) to cardiac rhythm disturbances (Stone et al. 1991b), trauma (Czarnik et al. 1991) and even cardiac arrest and death (Marx et al. 1968; Fiorentini 1992; Raymond 1995). In view of these issues, it is imperative that health care professionals are aware of these risks and are able to practice according to current research recommendations. However, previous work that was undertaken as part of this programme of research identified that individuals were unaware of current recommendations and practice based on ritual and tradition as opposed to empirical evidence. This thesis compares the effectiveness of standardised education with individual performance feedback on nurses and physiotherapists' knowledge and practice of tracheal suctioning. The overall aim of the study was to determine knowledge and practice of suctioning after conventional teaching and to investigate the effectiveness of tailored performance feedback over time.

A number of authors have reported difficulties in implementing and sustaining change in clinical practice (Grol 1992; Kanouse et al. 1995; Robertson et al. 1996). There is evidence that standard education, in the form of a conventional lecture, has little influence on knowledge and skills retention (Dubbert et al. 1990; Khatib et al. 1999). Performance feedback, tailored to the individual practitioner, has been put forward as a possible mechanism for implementing change and sustaining improvements over time (Grol 1998; Ryan and Lauver 2002). The findings of this study highlight performance feedback as a powerful mechanism for improving practice and it is suggested that this framework could be a useful approach for other aspects of critical care in order to implement research and ensure that practice is evidence based.

1.2 Evidence based practice

The ability to analyse and synthesise the available scientific evidence has become increasingly important to health care professionals (Warner et al. 1998; Parkin 1998; Witejunge and Baldock 1998). Indeed, one of the goals of nursing is to strengthen the scientific foundation that underpins practice (Taylor-Piliae 1998). Over the past ten years the NHS Research and Development Strategy (NHSE 1996a) has increased the evidence base regarding cost and clinical effectiveness. As a consequence, health policy is fully committed to the evidence based practice and clinical effectiveness initiative (NHSE 1996a; 1996b; 1996c), which has led to the production of clinical guidelines and protocols to guide practice. Clinical guidelines are systematic and logical statements to assist practitioners with decisions about specific clinical situations (Field and Lohr 1990). However, whilst there is some evidence that clinical guidelines can indeed improve the quality of care (Grimshaw and Russell 1993), there is increasing concern about the extent to which these guidelines are used in practice (Woolf et al. 1999).

In critical care, the NHS Modernisation Agency (2003) introduced the concept of "care bundles" to guide practice. Care bundles are groups of evidence based interventions, designed to improve patient outcome (Institute for Health Care Improvement 2005). As Fulbrook and Mooney (2003) argued, the effect of the whole care bundle is greater than the sum of its parts. Tracheal suctioning forms part of the tracheostomy care bundle and was introduced in 2002. However, as Scholes (2006) acknowledged, care bundles are very much in their infancy and their development continues through links with the critical care networks.

The purpose of the evidence based practice initiative is to enable practitioners to be competent in making sound clinical judgements and decisions about interventions that are based on empirical evidence as opposed to ritual and tradition (Felch and Scanlon 1997; Muir Gray 1997; Nolan et al 1998). This is important to all nursing and allied health professionals in order to provide patients with clinically effective health care within the available resources (Coyler and Kamath 1999). Clinically effective interventions based on the least cost will mean that scarce health care resources can be used more efficiently.

French (1999) argued that even in the late 1990's many practices were based on experience, ritual, tradition and common sense and, despite an increasing body of knowledge about the effectiveness of certain interventions, there remains a discrepancy between theoretical knowledge and practical application. Hunt (1996) argued that there are a number of reasons for this lack of implementation of research findings. These range from lack of knowledge to lack of understanding about the research findings. Hunt (1996) also suggested that the research findings might not be believed by some practitioners, or able to be implemented. These potential barriers to research utilisation pose a threat to the evidence based practice initiative (LeMay et al. 1998).

1.3 Clinical competence

According to the British Association of Critical Care Nurses (BACCN 2003), a nurse is deemed to be competent when he or she demonstrates the necessary knowledge and skills to carry out a specified task. There are a number of key contemporary driving forces that have led to the development and implementation of competency based frameworks in the NHS (DoH 2000a; 2001a; 2001b; National Audit Commission 2001). Scholes (2006) believes that the development of education and training packages that incorporate core skills and competencies, as opposed to professional qualifications, is consistent with the political agenda of blending roles across professional boundaries. This also fits in with the concept of the "skills escalator" (DoH 2001a). However, whilst it is fundamentally important to ensure that practitioners are competent in performing a specified skill, the definition of what is meant by "competence" has historically been problematic (Milligan 1998; Scholes 2006). Furthermore, the challenge of developing objective, valid and reliable tools to assess clinical competence has remained controversial (While 1991; While 1994; Coates and Chambers 1992).

According to Erault (1998), the term "competence" has two distinct meanings: *"a socially situated concept – the ability to perform tasks and roles to the expected standard"* and *"as individually situated, a personal capability or characteristic"* (Erault 1998, p 127).

Other educationalists describe competence as the successful integration of theory and practice (Milligan 1998; Scholes et al. 1999). Watson et al. (2002), however, have argued that there are major difficulties with the term "competence", as it has been defined so many ways by different people and is therefore open to interpretation. They go on to say that this has also led to confusion about the term performance. According to Erault (1994), performance is concerned with the ability to undertake something. However, there is a lack of consensus as to whether performance demonstrates competence or simply the ability to perform (While 1994; Erault 1998).

Erault (1998) argued that this lack of consensus has not only impacted on the way in which competence is defined and operationalised, but also the way in which it is measured. As Howard et al. (1990) highlighted, there are many strategies available to assess and evaluate practice, leading to potential ambiguity, inaccuracy and subjectivity. Attempts have been made to address these issues by identifying levels of competence (Benner 1984; Bondy 1983; Benner 1996). However, clinical judgements still need to be made. Erault (1998) argued that whilst there might be some disagreement over the level of competence, there is likely to be less disagreement as to what constitutes incompetence.

In spite of these issues, with the introduction of *Agenda for Change*, it has been necessary for managers to ensure that competency frameworks are in place. Many NHS Trusts have attempted to address these issues by producing multi-professional competencies in order to assist practitioners through the various gateways for banding within the new grading structure. Occupational standards and evidence-based practice have provided a strong foundation in the expression of competence, and health care professionals look for opportunities to acquire and refine competencies (Jones 2002; Bench et al. 2003).

In critical care, the Department of Health funded a national project to identify a competency framework for team competencies (Manley 2005). The objectives of the project were to undertake a values clarification exercise involving key stakeholders and critical care practitioners across the United Kingdom. Following thematic analysis, a number of standard statements were identified. These will form the basis of a national framework for critical care competencies. *Skills for Health*, licensed competency developers for the Department of Health, have been commissioned to take this work forward using the NHS Knowledge and Skills Framework (KSF) in order to identify a national set of core competencies for critical care that are based around the needs of the patient. Although the structure of the competency framework has not yet been identified, it is envisaged that tracheal suctioning will be incorporated into the respiratory elements of the framework.

1.4 Tracheal suctioning practices

The principal goal of airway management is to establish and maintain a patent airway in order to ensure adequate alveolar ventilation, oxygenation and gas exchange (Dean 1997). The effective management of an artificial airway is crucial in the management of the sick patient towards promoting physiological independence (Laws-Chapman 1998), improving patient outcomes, and preventing re-admission to intensive care. Suctioning has been identified as an important intervention for maintaining airway patency (Wainwright and Gould 1996; Wood 1998a,b). However, the procedure has been identified as potentially hazardous with many associated risks and complications. These complications pose not only additional risks to the critically ill patient, but also considerable financial cost to the National Health Service (NHS) in general.

In view of such hazards, there is an increasing body of evidence to suggest how and when suctioning should be performed. However, in spite of the available evidence, clear guidelines and protocols are often lacking in the practice setting. Moreover, suctioning appears to be performed on an individual basis with varying techniques and with little reference to research. This was clearly demonstrated in two earlier studies that were undertaken as part of this research programme. Both studies have been published in detail elsewhere, and are included as additional material with this thesis. A number of other studies have examined suctioning practices using questionnaire surveys (Tanser et al. 1997; Brooks et al. 1999). Brooks et al. (1999) conducted a questionnaire survey among physical therapists, nurses and respiratory therapists and found widespread variations in practice. However, to date only studies undertaken as part of the present research programme have investigated knowledge and practice through the use of observation as opposed to self-report (Day et al. 2001; 2002b).

Using an experimental design, the first study (see Appendix 1, Day et al. 2001) evaluated the effectiveness of a teaching intervention on knowledge and practice. The sample consisted of sixteen intensive care nurses and the study took place within a large inner London teaching hospital. Although there was an initial variation in performance amongst the nurses with little evidence of research underpinning practice, the results showed highly significant improvements in knowledge ($p = 0.001$) and practice ($p < 0.001$) following the teaching intervention. However, whilst these improvements were sustained at the four-week post teaching assessment ($p = 0.003$), there was some evidence that practice had already started to deteriorate. It was recommended that further research should be undertaken to investigate the effects of educational interventions over time. This was the first study to evaluate the effectiveness of education on suctioning techniques and make comparisons between knowledge and practice.

The second study was an exploratory study that was designed to explore nurses' knowledge and competence in performing tracheal suctioning outside of the ICU environment (see Appendix 2, Day et al. 2002b). This was a descriptive study that produced both quantitative and qualitative data and enabled comparisons to be drawn between knowledge and practice. The sample consisted of twenty-eight nurses from two wards and one high dependency unit within a large inner London teaching hospital. Like the previous study, knowledge and practice did not appear to be based on current research recommendations. There also appeared to be a weak correspondence between knowledge and practice. Many nurses failed to demonstrate an acceptable level of competence, and some of the practices observed were potentially unsafe. These support findings of the previous research study and of others (Celik and Elbas 2000).

A number of other studies have also reported a lack of association between knowledge and practice (Day 1995; Gould et al. 1996). These two studies were the first to examine tracheal suctioning through observation as opposed to self-report. No studies have examined the role of therapy staff in relation to their tracheal suctioning practices. In order to implement safer suctioning techniques and minimise the risk of tube-related complications, it is essential that all health care professionals are familiar with current research recommendations.

Tracheal suctioning is an important intervention that should be based on the best available evidence. However, as Thompson (2000) argued, it is important to acknowledge that many studies are small in scale, have inherent flaws and methodological weaknesses and are not necessarily based on an appropriate hierarchy of evidence. Thompson (2000) published a *Best Practice Recommendation Sheet* on the basis of a systematic review undertaken by the Joanna Briggs Institute, comparing the available research according to the classification system of six levels of evidence, as shown in Table 1.

Table 1.1: Classification system of levels of evidence

Level	Descriptor
I	The strongest, includes evidence from a systematic review of all relevant randomised control trials (RCT's)
II	Evidence obtained from at least one well-designed RCT
III.1	Evidence obtained from well-controlled trials without randomisation
III.2	Evidence obtained from well-designed cohort or case study controlled analytic studies, preferably from more than one centre
III.3	Evidence obtained from multiple time series with or without intervention
IV	Includes the opinion of respected authorities, based on clinical experience, descriptive studies or reports of expert committees

The Joanna Briggs Institute for Evidence Based Nursing and Midwifery (2000).

In her review, Thompson (2000) identified many issues relating to the quality or design of studies pertaining to suctioning. For example, studies had small sample sizes, lacked methodological rigor, often involved only one centre and the reporting of the methods and/or results was often incomplete. Thompson (2000) argued that these issues could undermine the validity of the findings and suggested that the results should be interpreted carefully. It is without question that nursing practice should be based on the best available evidence. It is widely acknowledged that when making decisions about patient care the hierarchy of evidence, which recognises the RCT as the strongest level, is clearly appropriate. However, in relation to suctioning, other qualitative methodologies can be helpful in assessing thoughts and feelings or establishing the opinion of experts.

1.5 Chapter summary

A number of studies have examined the relationship between knowledge and practice (Day 1995; Gould et al. 1996) and have shown discrepancies. Whilst there is some evidence from previous research in the ICU setting that knowledge and practice of endotracheal suctioning improved as a result of an educational intervention, a number of studies have also shown that such an intervention alone does not result in sustained improvements (Dubbert et al. 1990; Khatib et al. 1999). This was indeed apparent within the ICU setting, as for some nurses practice had already started to deteriorate as soon as four weeks after teaching.

The role of multiple interventions, including performance feedback, to achieve improvements over time has been put forward as a way of addressing these issues, and a possible framework for future research (Conly et al. 1989; Pittet et al. 2000). This study was therefore designed to evaluate the effectiveness of performance feedback as a strategy to improve nurses and physiotherapist's knowledge and practice of tracheal suctioning. As suctioning is such a fundamental aspect of airway management, it goes without saying that practitioners must be competent in this essential clinical skill. Appropriate technique and adherence to evidence based guidelines will result in fewer complications for the patient and, ultimately, financial benefit to the NHS, with fewer patients returning to the critical care unit with tracheostomy tube-related complications (Chen et al. 1998; Heathfield et al. 1999; Lewis and Oliver 2005). Whilst this study has focused on tracheal suctioning, there are nevertheless many other equally important clinical skills. It is envisaged that other aspects of clinical practice could be evaluated using the theoretical framework that underpinned this study.

CHAPTER TWO: EDUCATION FOR HEALTHCARE PRACTICE
A REVIEW OF THE LITERATURE

2.1 Introduction

The aim of this review was to critically examine the literature relating to education for health care practice. This included issues surrounding learning theory and adult education, knowledge and skills retention, and the role of simulation as an education and evaluation strategy.

The literature search was undertaken using CINAHL (Cumulative Index of Nursing and Allied Health Literature), MEDLINE and Cochrane databases (for search strategy, see Appendix 8). For the purpose of this review, papers using a range of educational interventions were considered relevant to the theoretical framework of performance feedback as a mechanism for improving knowledge and practice. The range of education literature is summarised in Table 2.1

Table 2.1 The range of educational literature reviewed

Aspect of Education	Literature reviewed
1. Learning theory	Adult education Evaluating educational interventions
2. Knowledge and skills	Retention of knowledge and skills
3. Simulation	Simulation and use of scenarios
4. Conventional education	Standard intervention
5. Multiple educational interventions	Performance feedback Reminders

Bero et al. (1998) argued that although there has been a considerable amount of funding spent on research, little attention has been paid to ensure that research findings are implemented into clinical practice. Bero et al. (1998) also maintained that there are many types of educational interventions available to promote behavioural change amongst healthcare professionals, and that it is difficult to disentangle the effects of these interventions from more contextual factors. A number of authors have previously examined the challenges associated with implementing research into practice (Grol 1992; 1997; Robertson et al. 1996). Grol (1997) goes on to say that no single method is really superior, and that different change proposals might require different strategies to implement them. In order to consider the most appropriate strategy for delivering education and bring about behaviour change, a range of literature was reviewed (Table 2.1). The literature has been divided into the following sections: learning theory and adult education, knowledge and skills retention, standardised interventions and reinforcement interventions.

2.2 Learning theory and adult education

Jarvis (2002) described the didactic lecture as *"the most frequently employed teaching technique despite all the criticisms that have been levelled against it"* (Jarvis 2002, p. 117). A lecture is considered the conventional means of delivering factual information to an audience, and is largely teacher-centred (Entwistle 1997). Such teaching and learning methods have historically been used to teach science-based subjects, and were common place in nursing and physiotherapy education until recently. However, as a number of authors have argued, continual use of this strategy could have a negative impact on student motivation (Gow and Kember 1993) and interest (Newstead and Hoskins 2003).

Over the past decade, health care practice has moved away from being predominantly medically led as new nurse and other practitioner led roles and responsibilities have emerged (Banning 2005). An example of this is the introduction of the Consultant Nurse and Consultant Physiotherapy roles in critical care, whose roles cross traditional nurse-physiotherapy boundaries in the provision of care for this patient group. Banning (2005) argued that, in view of this, education has moved away from a didactic approach to one of facilitation, which requires the lecturer to use alternative strategies for teaching and learning (Griffin 2002, Jarvis 2002).

Although the lecture remains a useful teaching method, it needs to be complemented by interaction if meaningful learning is to occur. Consideration needs to be given to the adult learner's attention span and learning style, as well as their experience and desire to participate. In relation to clinically based education, Rogers (1989) stated that the skills to be taught should be grounded in reality and represent the "real world". Laurilliard (1997) suggested that for a specific skill to be understood it should be dissected into sub-components in order for the learner to visualise that skill, and practice is an important component.

Alternative teaching strategies include more radical pedagogical approaches such as simulation, problem and enquiry based approaches (Banning 2005). Within this context, learning becomes more student-centred and the teacher is no longer seen as the person imparting knowledge but one of facilitating learning. This has a number of advantages for the adult learner, as they are able to engage in the intellectual processes, problem solve, share experiences and even challenge others (Haith-Cooper 2000; Gregory 2002; Haith-Cooper 2003). However, in order to succeed in this approach, lecturers need to have a sound knowledge base, be skilled in its approach and be flexible.

2.3 Knowledge and skills retention

The problems of retaining knowledge and skills over time have long been documented (Wright et al. 1989; Corner and Wilson-Barnett 1992; Moser and Coleman 1992). In their evaluation of an educational intervention pertaining to the newly qualified nurse and the cancer patient, Corner and Wilson-Barnett (1992) demonstrated that although initially there were substantial benefits to those who received the intervention, these were less obvious three months later. Many of the studies relating to cardiopulmonary resuscitation (CPR) skills retention have demonstrated that practice starts to decline as early as two weeks after initial training (Plank, 1989; Rivera-Tovar and Jones, 1990; Moser at al. 1990). Moser and Coleman (1992) suggested that knowledge does not decline at the same rate as practice skills, and as knowledge of Basic Life Support (BLS) does not necessarily correlate with skilled performance, the use of cognitive tests alone is not recommended.

In relation to CPR skills retention, Moser and Coleman (1992) reviewed a number of studies from 1980 to 1990. Although the sample sizes varied, the results of all studies reviewed demonstrated a significant reduction in knowledge and skills over time. In many of these studies, there had been a decline in CPR skills retention within two weeks of initial teaching and this continued in a progressive downward trend when tested at various intervals, reaching pre-teaching levels one and two years later (Deliere and Schneider 1980, Fossel et al. 1983, Gass and Curry 1983, Wilson et al. 1983). Moser and Coleman (1992) suggested strategies to improve CPR skills retention, including smaller class size and longer sessions, frequent performance feedback, detailed instruction, adequate practice with regular reviews two to four weeks after initial instruction, and periodic reviews every three to six months. It is, however, worrying that since these recommendations were made, more recent literature has failed to show any real improvements in knowledge and skills retention.

Using a quasi experimental approach, Broomfield (1996) tested nineteen nurses' knowledge and skills of CPR. Whilst an initial 3 hour update had revealed some improvement, there was a decrease in knowledge and skills ten weeks later, showing that retention was limited. These findings were statistically significant ($p = 0.000$). Broomfield (1996) concluded that knowledge and skills quickly deteriorate if they are not used in practice or regularly updated.

Chamberlain et al. (2002) undertook a randomised control trial to compare the effects of staged CPR teaching to conventional training. This was a large scale rigorous study involving 262 participants, of whom 166 were reassessed after six to nine months and 39 attended for extra training. Those in the experimental group received additional class and home based assessments. The findings demonstrated a deterioration in skills after six to nine months in most of the areas tested ($p < 0.05$). However, those who had attended retraining sessions tended to have less skill decay than those who received the standard conventional training session only.

In a longitudinal study using an experimental design, Greig et al. (1996) investigated the effects of regular practice on BLS skills retention. The study also aimed to investigate the effects of student-teacher ratio on performance, as Marsden (1989) had previously recommended a 6:1 student-teacher ratio. The experimental arm of the study was taught in groups of six, whilst the controls were in groups of 15 to 20 (as per conventional practice). Both groups showed an improvement following initial BLS teaching. Moreover, the experimental group continued to perform better in every category, which the authors attributed to individual support and coaching within the small groups and implied that using this model knowledge and skills can be retained over time.

Hammond et al. (2000) introduced an Advanced Life Support (ALS) course and tested 40 nurses' knowledge and skills 18 months after undertaking the programme. The findings demonstrated that theoretical knowledge was maintained over the 18-month time frame but practical skills were not, with 75% of the sample (n = 30) failing to pass the practical assessment. Although they gave no rationale for the 18-month time frame for assessment, the authors highlighted the problem of a dichotomy between the retention of knowledge and practical skills.

Similar findings are presented by Young and King (2000), who assessed knowledge and skills of life support using interviews, observation and mock scenarios following an ALS course. The nurses were assessed six and twelve weeks after initial teaching. The findings demonstrated that at the six-week assessment half (n = 5) achieved the pass mark for knowledge and half (n = 5) for practice. At the 12-week assessment, this had fallen further to less than half (n = 4) for knowledge and less than one third (n = 3) for practice. These findings generally support those of other studies. However, it is limited by a small sample (n = 10).

Handley (2002) compared teaching techniques for hand placement during chest compressions in a group of 65 lay volunteers in an attempt to improve the *Chain of Survival* in out-of-hospital cardiac arrests. Subjects were randomised to receive one of two educational interventions and were assessed six weeks after teaching. Initially both groups showed an initial improvement in accuracy in hand positioning but no significant difference between the groups (p = 0.345) or in the level of accuracy (p = 0.178). However, six weeks later, the standard intervention group showed a significant deterioration in skills (p = 0.001) whereas the experimental group did not (p = 0.561). Handley (2002) suggested that the method of skills teaching might influence the extent to which particular skills are retained.

Swor et al. (2003) also observed a low rate retention of CPR skills. Seventy-four older adults were randomised to receive either traditional BLS teaching or chest compression teachniques only and were assessed at three months. Overall skill retention for both groups was poor, with only 55% achieving competence in the chest compression group and 44% for the traditional teaching group. These differences were not statistically significant ($p = 0.586$).

In a prospective study, Woollard et al. (2004) evaluated the acquisition of BLS and automated defibrillation skills in the lay population. One hundred and twelve trainees were tested before and after a four -hour training programme and 76 were reassessed six months later. There was a general improvement in all CPR skills after initial teaching for all participants. However, at the six-month follow-up, all skills except chest compressions had deteriorated.

In a different area of practice, Reynolds (1999) measured the impact of an educational programme on bandaging skills. Using a quasi-experimental research design, 23 community nurses were taught the skills of bandaging and assessed using a knowledge- based questionnaire and structured observation six to ten weeks after teaching. The results demonstrated that prior to teaching only 30% ($n = 7$) obtained an adequate or good level of proficiency, but this improved significantly ($p = 0.005$) after teaching ($n = 20$, 87%). However, at the six to ten week follow up, this had decreased to 44% ($n = 8$). The author suggested that compression bandaging skills do decay over time, which supports findings of other studies. However, due to the small sample size and the possible Hawthorne effect, the findings cannot be generalised. The author also acknowledged that the training programme had not been validated.

The results of these studies suggest that using conventional teaching strategies alone there is an inevitable reduction in knowledge and skills retention over time. Some authors (Chamberlain et al. 2002; Greig et al. 1996; Handley 2002) also suggest that conventional teaching strategies may contribute to skill reduction and recommend offering regular refresher courses (Broomfield 1996) or the restructuring of educational methods (Grieg et al. 1996; Handley 2002). However, some authors have presented conflicting findings.

Inwood (1996) undertook an exploratory study to examine knowledge of resuscitation and investigated the effects of a workshop using questionnaires at three and six month intervals among 62 critical care nurses. No significant differences were found between the results of the second and third questionnaire, which indicated that there was no noticeable deterioration in knowledge levels over time. Inwood (1996) concluded that in view of these findings, there is no need for practitioners to undertake workshops every six months, although acknowledged that there is evidence to support annual updates. This study is limited in that it only examined knowledge which, as Moser and Coleman (1992) argued, does not necessarily correlate with performance. They also suggested that knowledge based tests alone are not recommended. However, other authors have examined practice and also demonstrated no significant deterioration in skills over time.

Handley and Handley (1998) undertook a randomised control trial to compare the effects of a four and eight step approach to BLS teaching. All participants ($n = 48$) were assessed at baseline level and were subsequently retested one and six weeks after teaching. Both groups' median scores improved significantly ($p = 0.001$) immediately after teaching and at the six-week assessment there was no significant skill decay in either group ($p = 0.900$, $p = 0.700$). One particular feature of this study is the step approach and small group teaching (as recommended by Marsden 1989 and Grieg et al. 1996), which could have influenced the results.

Some authors have suggested that performance feedback can have a positive influence on knowledge and skills retention. Kovacs et al. (2000) undertook a randomised control trial to examine the effect of performance feedback on the retention of airway management skills. With a convenience sample of 84 science students with no prior experience of airway management, participants were randomised to one of three groups; no feedback or practice after teaching (control group), independent practice plus three performance feedback sessions or performance feedback sessions only. After initial teaching, there were no statistically significant differences in mean scores between the groups ($p > 0.05$). However, at the sixteen-week assessment, those in the practice and performance feedback groups had significantly higher mean scores than the control groups ($p = 0.047$), and these trends were maintained at the 16 and 40 week assessments. The control group scores remained low at all intervals without significant change. However, the independent practice and feedback scores were significantly higher than the control group throughout ($p < 0.02$), and higher than the feedback only group. The results support the use of independent practice plus performance feedback as a way of promoting the retention of knowledge and skills.

Similar results are presented by Wik et al. (2002), who undertook a randomised control trial to investigate the retention of BLS skills after teaching with an automated voice advisory mannequin system to provide performance feedback. All participants ($n = 35$) received initial training with the computer based advisory feedback. The experimental group subsequently had an additional ten, three-minute, training sessions over the following month, which the authors referred to as the "over trained" group. The results demonstrated that after initial teaching both groups improved and there were no significant differences between groups ($p > 0.05$). At the six-month assessment, the control group scores were not significantly different from baseline pre-teaching levels. However, the group who had received extra training and feedback had better retention of skills. This suggests that over training and providing performance feedback can have a positive influence on knowledge and skills retention.

In reviewing these studies, the majority of findings have demonstrated a discrepancy between knowledge and practice after an educational intervention, and have highlighted a deterioration in practical skills over time. This supports the findings of studies reviewed by Moser and Coleman (1992) and might suggest that little progress on strategies to limit the theory practice gap has been made. Many studies have used three or six-month time frames to assess practice, which suggests that the retention of practical skills could deteriorate within that period. Scholes and Endacott (2003) argued that if practitioners are not regularly exposed to certain clinical skills they are unable to refine and perfect these techniques. They refer to this as the *"practice competence gap"*. This might explain why some skills are retained whereas others are not. A number of authors have recommended including performance feedback as a method of promoting the retention of skills (Kovacs 2000; Wik et al. 2002). This would seem a sensible strategy to adopt, especially for teaching a complex skill such as tracheal suctioning, where practitioners might not necessarily be exposed to this skill on a regular basis. The multiple interventions model, including performance feedback, has been used as the framework to underpin this study and promote the retention of both knowledge and skills in an attempt to reduce the "practice competence gap" identified through previous research.

2.4 The use of simulation in education

Simulation is defined as an imitation of reality, often in a simplified format. According to Quinn (2000), simulation aims to put the participant in a position where they can experience an aspect of real life by becoming involved in activities that are directly related to it. Jones (1985) defined simulation as:
"an untaught event in which sufficient information is provided to allow the participants to achieve reality of function in a simulated environment". (Jones 1985, cited in Wildman and Reeves, p 207)

Wildman and Reeves (1997) argued that this enables the participants to engage with functional roles in an environment that is consistent with the real world. Edwards et al. (1995) suggested that the objective of the simulation should not be to replace the real experience, but to equip the practitioner with skills that can be transferred to the actual clinical setting. Cioffi (2001) argued that this will increase confidence and competence. However, several authors believe that problems of definitions arise in attempting to analyse simulation as an educational or assessment strategy (Jones 1980, Roberts et al. 1992).

In the airline industry, flight simulation has been used since the 1930's and is mandatory for all pilots, who are required to undergo training exercises in which they are controlling a virtual airplane in distress (Jones 1982, Roberts et al. 1992). Within this context, simulation is used both as a training and evaluation method. This period also marked the first attempts to incorporate simulation into medical curricula. During the past ten years, simulation has extended into other healthcare programmes, including physiotherapy, dentistry and, more recently, nursing. Roberts et al. (1992) argued that there has been a varied response to the use of simulation from early optimism to a degree of caution. Issues around the effectiveness of simulation as an evaluation tool, cost effectiveness and time have been identified as possible limitations (Barnett 1984; Winter and Vásquez-Abad 1981). Gates et al. (2002) suggested that there are also issues surrounding the validity and reliability of this evaluation strategy, and the ability of the author to produce a realistic patient scenario that is consistent with reality over time. Some role-play simulation exercises involve the use of patient actors as "standardised patients". The importance of the actor or actress becoming familiar with the clinical setting and portraying a consistent role over time cannot be over emphasised.

Gates et al. (2002) stated that much of the existing literature has focused on the usefulness of simulation in relation to teaching skills as opposed to a measurement or evaluation strategy. There are also issues surrounding the most appropriate location for the acquisition of such skills, and whether this should be in a clinical or laboratory style setting (Roberts et al. 1992). Unfortunately the empirical evidence to support this is limited. Gomez and Gomez (1987) undertook a randomised control trial to assess student nurses ($n = 63$) performance of blood pressure measurement. One group was taught on a gynaecological ward and the other in a clinical skills laboratory. Performance was evaluated in a residential nursing home. The findings showed that the students taught in practice had significantly higher scores ($p < 0.05$) for both accuracy and level of confidence of blood pressure measurement. However, the study is limited by a relatively small sample size.

Similar findings have been presented in the field of dentistry. Chan et al. (2000) studied the effectiveness of simulation in a group of dental students where a simulation laboratory had been in use for five years. When the course was reviewed, the number of A grades had decreased from 22.7% to 4.5% whereas the number of B and C grades had risen significantly. The authors attributed these findings to the unreal environment and difficulties associated with performing on a dental simulator.

In an attempt to justify the use of simulation in a laboratory style setting, Clancy et al. (2002) undertook a study to compare student performance of fixing full cast dental crowns in a simulation clinic and a traditional laboratory environment. The study compared the scores of two fixed preparations; one made in a simulation clinic, the other on a bench top. The sample size consisted of 99 dental students, and comparisons were made between group one (year one students, no prior experience in a simulation clinic), group two (year two students, one years experience) and group three (year three students, two years experience). Three independent faculty members scored the students. In addition, all students completed a questionnaire to assess their perceived readiness prior to treating their first prosthodentic patient. The findings showed highly significant differences in scores between groups (P = 0.001) for the teeth prepared on the bench top but not for the mannequin (p = 0.1176). The questionnaire revealed that the majority of students had perceived their clinical readiness to treat patients as adequate. The results of this study are mixed as students with more bench top experience scored better than those with limited experience and those with more mannequin experience scored equally in both groups.

Problems also arise in developing the simulation packages, which are expensive and time consuming to prepare and implement, often requiring a number of trial runs and modifications prior to implementation. However, in spite of these limitations, Gates et al. (2002) remind us that it is important to consider their value as a measurement or evaluation strategy for research. Simulation provides practitioners with the opportunity to perfect their skills in the "real life" context, thus protecting the patient's privacy, dignity and confidentiality, without causing any undue discomfort or pain. This is particularly important for vulnerable patients such as the critically ill. Simulations can also be used in research, with an appropriate research instrument, such as an observation schedule, or videotape recording. Simulations can therefore be a more objective way in evaluating performance (Roberts et al. 1992). In circumstances where there is more than one observer or if the simulation is videotaped, researchers are able to demonstrate an effective inter rater reliability whilst evaluating clinical skills, which is an important aspect of observational research. It is also important to note that in certain circumstances it is simply not possible for some clinical skills to be performed with a patient actor or even in an actual clinical setting. In such cases, role-play simulation using a mannequin designed for evaluating these skills might be considered more appropriate. Indeed, simulation with mannequins will not only enable the educator to evaluate skill acquisition and competence, but also provide feedback on performance with suggestions for improvement (Gates et al. 2002; Alinier et al. 2004). Nevertheless, in spite of which strategy is adopted, issues of validity and reliability are essential and must always be considered.

Cioffi (2001) argued that when simulations are developed, essential information must be presented in a way that mimics reality. Rimoldi (1988) goes on to say that there are two main types of presenting information within a simulation; the response based and the process based method. In the response based method, the practitioner is given details of an actual patient case study, has no control over the data presented and does not actively search for new information. This method standardises the information given to all participants and may be appropriate for a structured evaluation of clinical skills, such as in non-participant observation (Jones 1989). However, this method has been criticised, as in the search for information, the participant may seek alternative details, which some authors believe could alter thinking and decision making (Jones 1989; Cioffi 2001). This could question the validity of this approach (Norman and Feightner 1981; Zemper 1982).

The process-based method is sequenced over time, the participant is an active searcher and has control over the information. Examples include patient role-play scenarios and videotaped vignettes. The learner is able to actively request information about the patient and is able to control the data, which enables progression over time at the participant's own pace. Cioffi (2001) argued that this approach partially addresses criticisms about simulations not representing reality, as all of the information is not necessarily needed at the outset. The nature of the assessment changes as the scenario progresses, and the assessment is not, therefore, standardised (Barrows and Feltovich 1987). This approach might have more ecological validity, encourage critical thinking and, indeed, achieve a greater representation of reality. However, in structured situations where the method of assessment needs to be standardised, as in a randomised control trial, there may be inevitable problems with measurement.

Cioffi (2001) suggested that if simulations are to be designed for evaluation or assessment purposes, the characteristics about the context of the simulation need to be considered. She argued that because health care professionals are faced with complex and uncertain clinical situations, it is important to ensure that there are varying degrees of uncertainty within the simulation. This could be interpreted by ensuring that there are a range of possible outcome variables or actions that could be undertaken. Decisions taken would depend upon clinical judgement, regardless as to whether the simulation is process based or response based. The nature of uncertainty will no doubt vary with the level of skill and degree of clinical judgement that is being assessed. For example, in medical simulations involving complex tasks associated with an uncommon clinical problem, there might be a low prediction of decision variables (i.e. a higher level of uncertainty) and a lack of available data (Bala 1985). However, for simulations involving basic skills associated with more common clinical problems, such as tracheal suctioning, there might be a much higher prediction of decision variables (i.e. a lower level of uncertainty) and more available data.

A similar but alternative method of evaluating clinical performance is the Objective Structured Clinical Examination (OSCE). Harken et al. (1975) defined the OSCE as: *"... an approach to the assessment of clinical competence in which the components of competence are assessed in a well planned or structured way with attention being paid to the objectivity"* (Harken et al. 1975, p 19)

The OSCE first originated from medical education in the UK, USA and Australia (Harken et al. 1975). From the literature there is evidence of its use in occupational therapy and physiotherapy during the late 1980's and early 1990's (Edwards and Martin 1989; Neyer 1993) and, more recently, in nursing (Ross et al. 1988).

Harken et al. (1975) described the OSCE as a series of work stations through which the student rotates to test a broad range of skills and knowledge. Each station has a number of set objectives, which exposes the student to a clinical problem and requires a response. The objectives could vary from the requirement to perform a clinical skill to answering a set of questions or communicating with a "patient". The OSCE has been found to be a valid and reliable method of assessing clinical performance (A-Latif 1992; Matsell et al. 1991; Sloan et al. 1993). Miller (1990) illustrated the dimensions of the OSCE with a pyramid in order to identify the level of skills that practitioners should be able to demonstrate. Within his framework, the baseline layer is knowledge (knows), followed by competence (knows how), performance (shows how) and, the top of the pyramid, action (does). Within this context, the OSCE can be used in a formative way to enhance skill development (Alinier 2003) or summatively to evaluate performance (Miller 1990).

The OSCE, like the use of role play simulation, has been criticised for being artificial, as clinical problems are presented in timed, compartmentalised components, which some authors argue is of questionable validity (Rogers et al. 2000). However, Buckingham (2000) and Macleod Clark (1996) both agree that rehearsing clinical skills in a laboratory style setting removes the complexity of the clinical setting and makes it easier to objectively assess and evaluate the student's performance. Many nurse education curricula have attempted to address the well documented profile of a lack of clinical skills (Macleod Clark 1996) by introducing the OSCE at pre registration level. It is envisaged that by re-introducing clinical skills laboratories, the use of role play simulation combined with an OSCE framework to evaluate skills might be seen as a way forward for strengthening the relationship between theory and practice and ensure that practitioners are fit for purpose (O'Neill and McCall 1996).

Alinier et al. (2004) reported the findings of a study using simulation undertaken at the University of Hertfordshire. The study aimed to evaluate the effectiveness of scenario based simulation on student nurses' confidence and competence, and took place in the Hertfordshire Intensive Care and Emergency Simulation Centre (HICESC), a three bedded adult simulation ICU. The simulation platform was a *Laerdal SimMan* Universal Patient Simulator, a full body trainer which, for skills such as advanced life support (ALS) and airway management, has been shown to be as effective as using live patients (Roberts et al. 1997). This was a complicated simulation that consisted of a three-hour session and was assessed via two OSCE stations. A total of 101 students took part in the study, although some subsequently withdrew ($n = 34$) due to time constraints. The sample were randomly assigned to groups; the experimental group were exposed to simulation whereas the control group undertook the conventional nursing programme. The findings demonstrated that the experimental group's performance had improved over the control group (13.43%, compared to 6.76%). These findings were statistically significant ($p < 0.05$). Feedback from both lecturers and students indicated that simulation is valuable as a training and evaluation tool (Aliner et al. 2004). However, like Roberts et al. (1992), they recommended a degree of caution, as a good tool is only as good as the way in which it is used, and issues of training, validity and reliability are essential considerations. Aliner et al. (2004) also argued that simulation can never replace traditional methods of evaluation, as students will always need to learn and be assessed at the bedside with real patients (Hegarty and Bloch 2002).

2.5 Standard educational interventions

Only research connected to the present study has evaluated the effectiveness of an educational intervention on tracheal suctioning techniques. Indeed, no study, on current literature searching, has evaluated the effects of education on suctioning over time. However, whilst there is a dearth of literature in this area, there are studies that have evaluated the effectiveness of education on other aspects of clinical practice over time. Literature pertaining to alternative aspects of practice has therefore been reviewed as a foundation for this study.

Many of these studies relate to hand washing practice. One-off educational interventions have been found to have a short-term influence on nurses' hand washing behaviour (Dubbert et al. 1990; Khatib et al. 1999). Dubbert et al. (1990) observed the hand washing behaviour of 12 ICU nurses before and after four fifteen-minute teaching sessions about hand washing. The findings showed an increase in compliance from a baseline level of 81% to 94% the week after the intervention. However, compliance declined to baseline levels over the next three weeks.

Khatib et al. (1999) presented similar findings in their study of the effectiveness of education on hand washing in ICU. The standardised intervention consisted of formal lectures, practical demonstrations and written information about hand washing. Of the 537 episodes of observation, compliance was high (78%) the week after the intervention. However, compliance fell to 48%, 27% and 29% over the next three weeks.

However, one study showed conflicting results. Baker et al. (1998) used an educational video to teach hand washing to six care workers at centres for people with disabilities. There was an initial improvement in hand washing frequency following the education and this was sustained over the following six months.

These studies generally suggest that one-off standardised educational interventions might result in short term improvements in practice only.

2.6 Multiple educational interventions

Within the literature, there is some evidence to support the role of multiple educational interventions for targeting specific barriers to change (Bero et al. 1998; Effective Healthcare Bulletin 1999; McLaren and Ross 2000). Bero et al. (1998) described these as *multifaceted interventions*, and undertook a systematic review to identify the evidence base for strategies most likely to bring about behavioural change. Passive dissemination of information or clinical guidelines alone were felt to be inadequate, and recommended a more active multifaceted approach at local level. More recently, however, the benefits of multifaceted interventions have been questioned. In their systematic review, Grimshaw and Eccles (2004) found that most dissemination and implementation studies resulted in only small or moderate improvements in care. They argued that multifaceted interventions are not necessarily more effective than a single intervention and suggest that further work is needed to test such a theory in the health care setting.

In their study of the South Thames Evidence Based Practice (STEP) project, McLaren and Ross (2000) used a multifaceted approach to implementing changes in practice based on a combination of clinical guidelines, audit and feedback, leadership and education. A model was developed, incorporating interactions between continuing education, audit and research findings, in an attempt to implement and evaluate evidence-based practice in nine diverse clinical settings across South London. In evaluating the effectiveness of this model of change, Redfern et al. (2000) concluded that the STEP project was highly successful in managing change in complex environments. In general, the educational interventions worked and the project leaders were felt to be fundamental to the success of the change process. Issues of training and education, motivation and commitment to change, and available resources were identified as key factors to implementing and sustaining change, as well as recognition of the positive impact on patient care (Redfern et al. 2000).

More specifically, individually tailored interventions are thought to have a positive impact on behavioural change (Moulding et al. 1999). Ryan and Lauver (2002) reviewed twenty studies comparing the use of tailored informational interventions to standard interventions. In fifty percent of studies, participants preferred the tailored interventions, which they remembered and felt were more personal. However, in some of the studies the effects were equivocal. Ryan and Lauver (2002) concluded that tailored interventions could be improved by identifying the most salient features to be tailored, determining the essential features, the efficiency of delivery channels and clarifying the effects of changes over time.

A number of studies have examined the effect of combining multiple interventions as a method of improving practice. Conly et al. (1989) investigated the effect of education, feedback, review, reminders and modification of policies and procedures on hand washing practices in a medical ICU. The intervention was reported as a multi-pronged approach and was implemented on two occasions during the first and fifth year of a five-year study. After the first intervention, hand-washing frequency increased from 28% to 81%. This increased from 23% to 60% following the introduction of the second set of interventions. This was associated with a decrease in hospital acquired infection rates (HAI) of 18% after the introduction of the multifaceted interventions. There was a further reduction of 2% with the introduction of the second programme.

Berg et al. (1995) took a similar approach on an ICU over a three-month period, and evaluated the effects on hand washing and rates of HAI. The interventions included elimination of open receptacles containing sterile water, improvement in aseptic technique, closed urinary drainage systems and 15 education sessions relating to HAI. The frequency of hand washing after the intervention was much higher than before (63%, versus 5%; $p < 0.01$). There was also a significant reduction in HAI rates from 33% to 16% after the interventions.

In the Accident and Emergency (A & E) setting, Dorsey et al. (1996) examined the effects of using brightly coloured reminders above sinks and distributing educational material. Hand-washing frequency was observed before and after the intervention and findings showed a tendency for improvement after the intervention. However, the improvements were not significant ($p > 0.05$). The authors reported that nurses showed a greater compliance with hand-washing practices than their medical colleagues.

Raju and Kobler (1991) examined hand-washing practice amongst health care workers in a neonatal ICU. Following the baseline assessment, a multiple educational intervention programme was designed and implemented. This consisted of five educational sessions, in-service training during ward rounds, distribution of information about hand-washing and performance feedback. Compliance with hand-washing procedures increased significantly from 28.4% to 62.6% ($p < 0.01$) following the interventions. The authors stated that the health care workers were not aware that they were being observed prior to the intervention. However, they were aware of being observed following the intervention. Findings could, therefore, be attributed to the "Hawthorne Effect" as opposed to the other aspects of the interventions.

Larson et al. (1997) undertook a controlled study on a general surgical ICU (experimental unit) and neurosurgical ICU (control unit). Hand-washing frequency was observed before and after the implementation of a multiple intervention programme. This consisted of focus group discussions to improve knowledge, beliefs and attitudes to hand washing, and the installation of an automatic sink for the experimental unit. The findings showed that health care workers from the experimental unit washed their hands more often than the control unit (69% versus 59%; $p < 0.01$).

Pittet et al. (2000) monitored the effect of a hospital-wide hand hygiene campaign to improve compliance. Seven observational studies were undertaken on a twice-yearly basis. The campaign consisted of a number of interventions, including A3 sized colour posters, performance feedback and reminders. The findings showed that hand hygiene improved significantly from 48% at baseline level to 66% following the interventions ($p < 0.001$). However, whilst hand hygiene had improved significantly amongst the nurses and nursing assistants, for doctors it remained poor. There was also an associated reduction in nosocomial infections and MRSA transmission. The authors suggested that a greater compliance with hand hygiene protocols were a direct result of the hospital-wide campaign and multifaceted approach taken.

Other studies, however, have presented conflicting results (Simmons et al. 1990; Flottorp et al. 2002). In their study of hand-washing behaviour of a group of health care workers in a medical and surgical ICU, Simmons et al. (1990) demonstrated minimal improvements. The interventions consisted of in-service education (compulsory attendance), distribution of educational material, performance feedback, including an on-the-spot critique of hand-washing practices, and buttons encouraging good practice. Hand-washing frequency increased from 22% to 29%, but this was not significant ($p > 0.05$). There were no associated changes in HAI rates.

In a different area of practice, Flottorp et al. (2002) undertook a randomised control trial to improve the management of urinary tract infections in women and patients with sore throats. The aim of the study was to assess the effectiveness of multifaceted interventions to implement evidence based guidelines for the treatment of sore throats and urinary tract infections (UTI). The main recommendations were that most patients with sore throats do not need antibiotics, and that clinical examination and laboratory tests were not required. The recommendations for women (non-pregnant, aged 16-55 years) with a UTI were for symptoms to be treated with antibiotics without any urine testing. Seventy-two practices received the UTI guideline interventions and 70 practices the sore throat guideline interventions, serving as controls for each other. Fifty-nine practices completed the UTI study and 61 the sore throat study. The outcomes were measured through the number of sore throat consultations (16,939) and UTI consultations (9,887). The multifaceted interventions consisted of patient educational material (paper and electronic), computer based support, reminders, an increase in fee for telephone consultations and interactive courses for general practitioners.

The findings showed that patients in the sore throat intervention group were 3% less likely to receive antibiotics after the implementation of the interventions. Women with symptoms of a UTI in the experimental group were 5.1% less likely to have a laboratory test ordered. No significant differences were found between the groups for the number of telephone consultations. The authors reported widespread variation across practices in the rate of antibiotic prescriptions, laboratory tests and telephone consultations, and concluded that complex interventions targeted at identified barriers to change had little effect on practice. However, it is important to recognise that the interventions, whilst multifaceted, were delivered in a passive manner, which might have had an influence on the findings. The authors recognised that the interventions were not tailored to the needs of individual practices or, indeed, individual doctors and suggested that tailored interventions at local level might have had a greater effect.

It would appear from these studies that a multifaceted approach which combines education with written material, reminders and feedback on performance can have a positive effect on improving practice in certain circumstances. At least one study has suggested that if the intervention is sustained the effect can be maintained for a number of years (Conly et al. 1989). However, as most authors acknowledge, it is difficult to change practice and large changes over a short time frame is an unusual picture. It is therefore essential to use rigorous methods to measure the effectiveness of the interventions used before they are implemented, and to ensure that they are a cost effective and powerful way of overcoming barriers to change.

2.6.1 Reinforcement interventions

2.6.1.1 Reminders

A number of authors have suggested that interventions aimed at reinforcing knowledge and behaviour should be employed. Donowitz et al. (1986) believed that if health care workers were asked to wear gowns, this would remind them of the need for hand washing and other aspects of infection control. The effectiveness of this intervention was evaluated in a paediatric ICU. However, there was no significant difference in hand washing associated with gown use (34/78, 31%) compared to no gown use (25/84, 30%; $p = 0.250$).

McGuckin et al. (1999) evaluated the effects of asking patients to remind health care workers to wash their hands. This was supplemented with information labels on the patient's gowns. Data were collected by assessing the amount of soap used each day to estimate hand washing frequency six weeks before and six weeks after the intervention. Of the 441 patients contacted, 276 completed a telephone interview two weeks after discharge from hospital. In total 157 reported that they had asked a health care worker to wash their hands and 121 had received a positive response. In addition, there was a significant increase in the amount of soap used per bed area each day (34%; $p = 0.021$).

Khatib et al. (1999) investigated the use of reminders to improve hand-washing practices amongst respiratory nurses in ICU. Labels with information about hand washing and glove use were placed on all mechanical ventilators. The finding showed that frequency of hand washing was significantly higher both before and after patient contact (92% versus 46%, $p < 0.05$). The authors stated that hand washing rates were maintained over the following four weeks.

From these studies, the use of reminders would appear to improve hand-washing frequency in the clinical setting. However, none of these studies have evaluated the effectiveness of these reminders over a long-term period. In relation to the present study, reminders about suctioning would need to be a combination of verbal and written feedback and delivered to the participants on an individual basis, as posters or strategically placed notices would have an influence on the control group.

2.6.1.2 Performance feedback

A number of authors have also suggested that giving personalised feedback on performance can lead to sustained improvements in practice. This could take the form of oral one-to-one feedback, written or group feedback.

Dubbert et al. (1990) examined the effectiveness of performance feedback four weeks after an educational intervention. The feedback took the form of posters indicating overall group performance stating the hand washing errors observed the previous day. The results showed that 12 of the 18 nurses did not change their behaviour following the first week of feedback. However, the second week of feedback compliance had increased from 81% to 97% and these levels were sustained to the end of the four-week period.

Mayer et al. (1986) undertook a randomised control trial to evaluate the effects of feedback on hand washing. The feedback took the form of daily memos to individual staff about the previous day's performance. The feedback was given three weeks after the introduction of a particular type of soap to a medical ICU (experimental group). The surgical ICU (control group) received none of the interventions (soap or memos). Hand washing frequency improved from 63% at baseline level to 85%, 91% and 98% during following three weeks when memos were given.

Van de Mortel and Heyman (1995) evaluated the hand washing practices of 101 health care workers based on a combined ICU and HDU. The authors assessed the effectiveness of six weekly performance feedback in the form of charts that reported on practice. This took place over a period of five months. The findings showed a moderate increase in hand washing frequency during feedback. However, this was only significant for two professional groups (physiotherapists and doctors), where increases from 20% to 77% and 57% to 94% were reported. Furthermore, the authors stated that these improvements were sustained six months after the study was completed.

Tibbals et al. (1996) also investigated the effectiveness of personalised feedback on a group of 61 medical doctors working in a paediatric ICU. The feedback took the form of brightly coloured posters showing weekly results of hand washing. Following the feedback, hand washing frequency increased dramatically from 32% to 68% and from 33% to 63% before and after patient contact. The observation carried out seven weeks after feedback showed a lower frequency than during the feedback period but still four times higher than baseline levels.

Naikoba and Hayward (2001) suggested that feedback might work because the health care workers are being observed and behaviour might be altered consciously. It is difficult to blind health care workers to the observation process if they are getting feedback on performance. However, in spite of this, the findings of these studies do indicate that personalised and non-personalised feedback can improve performance.

2.7 Implications of the literature on the present study

The literature reviewed has highlighted some important issues. Whilst it is clear that an educational intervention can have a positive effect on knowledge and practice, there is evidence that a single intervention alone does not lead to sustained improvements over time. Studies have shown that knowledge and practice could start to deteriorate as early as two weeks after teaching (Plank and Steinke 1989; Rivera-Tovar and Jones 1990; Moser et al. 1990). The role of multiple interventions, which combine conventional modes of teaching with written material, reminders and performance feedback, have been put forward as a way of addressing these issues, and at least one study has suggested that if the intervention is sustained the effect can be maintained for a number of years (Conly et al. 1989). The study was therefore designed to evaluate the effectiveness of multiple educational interventions, with the key focus on performance feedback, to improve the practice of tracheal suctioning amongst health care professionals.

CHAPTER THREE: TRACHEAL SUCTIONING
A REVIEW OF THE LITERATURE

3.1 Introduction

Although this thesis is primarily about enhancing the retention of knowledge and skills following practice based education, including performance feedback, the process cannot entirely be divorced from the content of the education. In order to ensure that the content of the educational package was based upon current best evidence a comprehensive review of the literature was conducted.

The main purpose of this review was to critically examine and appraise the evidence base for tracheal suctioning. Best practice recommendations were subsequently formulated, using the highest possible sources of evidence (for search strategy, see Appendix 8). The literature also informed and underpinned the development of the research instruments (Appendices 9 and 10).

An initial search for literature was undertaken before 2002, as this informed the development of the research instruments used with the two earlier studies. This included literature published from 1966 to 2001. The search was undertaken using the Cochrane Library, CINAHL, MEDLINE, BNI (British Nursing Index) and AHMED (Allied Health Medicine) databases (see Appendix 8 for search strategies).

In 2002 the search was updated to ensure that the educational interventions were based on current best evidence. This search was undertaken using EBM (Evidence Based Medicine) reviews and the Cochrane Database of Systematic Reviews (see Appendix 8).

In addition to computerised searches, critical care journals were hand searched in order to identify potential reports of relevant trials, either in the form of articles, editorials, abstracts or letters. The journals were selected as they represent the majority of critical care literature where experts in the field tend to publish (see Appendix 8). This review includes literature published from 1966 until the present date. This review is restricted to studies published in English. Overall, a vast range of literature was reviewed covering all aspects of the suctioning procedure, as summarised in Table 3.1

Table 3.1 The range of suctioning literature reviewed

Aspect of Suctioning	Literature Reviewed
1. Rationale for suctioning	Indications for suctioning
2. Prior to suctioning	Patient preparation Hyperoxygenation and hyperinflation Normal saline instillation Infection control
3. During suctioning	Catheter size Negative suction pressures Depth of insertion Technique of catheter withdrawal Duration of procedure Number of suction passes
4. Post suctioning	Patient assessment Reduction of oxygen levels Patient reassurance Documentation

3.2 Tracheal Suctioning

The literature has been divided into three main sections: prior to suctioning; during suctioning and post-suctioning. This decision was based on earlier work, as the procedure was felt to naturally fall into these subsections. The design of data collection instruments, and subsequent data analysis, followed an identical format. Literature pertaining to endotracheal as well as tracheal suctioning was felt to be highly relevant, as there are few differences between the two techniques and the majority of research has been undertaken with the intubated patient or animal model.

3.2.1 Rationale for suctioning

The purpose of tracheal suctioning is to remove secretions. However, it is widely accepted that this should only be performed as clinically indicated, and not as a routine intervention (Dolan 1991; Pierce 1995; Glass and Grap 1995). Suctioning should therefore be performed following a comprehensive assessment of the patient's respiratory status, which should include chest auscultation (Glass and Grap 1995; Griggs 1998). Glass and Grap (1995) argued that this could contradict traditional values with ritualistic practices, and suctioning might be performed at routine time intervals.

Copnell and Fergusson (1995) described the criteria used by 24 paediatric nurses to assess the need for endotracheal suctioning. The responses from this small-scale study fell into two main categories; general factors relating to the frequency of suctioning and time intervals, and specific factors outlining the need for immediate suctioning. The authors suggested that this division in response might have been due to the respondents interpreting the questions differently. Indeed, one limitation of the study is that the questions used by the researchers were not tested prior to the main study. Different questions may have elicited responses that were more precise and increased the validity of the findings. Nevertheless, in spite of these factors, only 58% of the nurses (n = 14) were able to describe appropriate indicators for suctioning, which highlighted a serious knowledge deficit. This was especially worrying as 87% (n = 21) had more than 2 years paediatric ICU experience. Copnell and Fergusson (1995), however, believed their nurses were unable to express themselves well and stated that for some this was due to their experience, as they were functioning as "expert practitioners" and therefore using intuition to guide judgements.

Wood (1998b) also examined ICU nurses skills of assessing the need for suctioning. A group of seven ICU nurses were taught the skills of auscultation and how to assess when a patient required suctioning. Short-term ventilated patients were randomly assigned to receive suctioning either following a comprehensive patient assessment or at routine two hourly intervals. Findings were compared to patient outcomes, including oxygen saturation (SpO_2), airway pressures, heart rate and rhythm, mean arterial pressure and the quantity and quality of secretions obtained. Although the study did demonstrate significant improvements ($p < 0.001$) in knowledge of assessing the need for suctioning, it did not compare this to observed practice or look at suctioning techniques in detail, since this was carried out according to a standardised protocol. Wood (1998b) found that whilst there was a tendency for the higher grade of nurse (i.e. the more experienced nurse), to produce a lower score prior to the educational intervention, these nurses produced the highest scores after teaching. Wood (1998b) suggested that this could be due to experienced nurses making assessments and decisions so rapidly that they were unable to articulate them. This supports Copnell and Fergusson's (1995) theory. Wood (1998b) recommended that the study should be replicated in a similar setting and include ENT and long-term ventilated patients.

3.2.2 Prior to Suctioning

3.2.2.1 Patient preparation

The importance of reducing stress and anxiety in the acutely ill patient cannot be overemphasised. Most of the literature reviewed discusses the potential complications of suctioning and the need to minimise the risks to the critically ill patient. However, there is limited reference to preparing the patient for the procedure. Indeed, informing the patient's consent and encouraging their participation has been identified as a strategy for reducing distress and anxiety and maximising the effectiveness of suctioning (Demlers and Saklad 1973; Young 1984; Fiorentini 1992). Fiorentini (1992) argued that in unrelaxed patients with acute pain, the suctioning procedure itself and the cough produced might result in physiological and behavioural changes.

Suctioning is a most unpleasant experience for the patient, and has been described as a feeling of choking or loss of breath (Bergbom-Engberg and Haljamae 1989). Sawyer (1997) described his experience of being a patient in intensive care. He argued that being suctioned had been the closest he had come to *"hell on earth"* (p. 28) and suggested that some nurses were better than others *"In the hands of a skilled yet sensitive practitioner suctioning need not be more than a very necessary discomfort"* (p. 28). However, Sawyer (1997) used words such as *"horrific"*, *"coughing"*, *"gagging"* and *"choking spasms"* to describe the experience he calls the *"sink plunger"* technique (p. 29). This graphic description of suctioning highlights the importance of good patient preparation. However, many nurses still fail to adequately prepare their patients (Celik and Elbas 2000).

Celik and Elbas (2000) highlighted this very issue. Their study aimed to determine whether a standardised approach to endotracheal suctioning had an impact on patient care. Using an experimental design, the authors compared two different methods of suctioning; the standard suction procedure employed in their cardiac surgical ICU and a procedure developed according to current research. All patients had undergone cardiac surgery and the exclusion criteria included a history of Chronic Obstructive Pulmonary Disease (COPD), renal or neuromuscular disease, pacemaker and neuromuscular blockade. In addition, all patients were non-smokers, had blood gas and haematocrit values within normal parameters, were not connected to an intra-aortic balloon pump and were intubated with an arterial line in situ. The findings demonstrated that none of the nurses adequately explained the suctioning episode to patients. It is important to note that Ethical Approval was not obtained for this study, which the authors acknowledged as a limitation.

Claesson et al. (2005) presented similar findings. This study reported findings of a small-scale study aimed at describing the experiences of mechanically ventilated patients. This formed part of a much larger national project to investigate sedation practices within Swedish ICU's. Prior to commencing the study, an assumption was made that patients who are not heavily sedated are able to remember more about their ICU stay and suffer less memory gaps than their sedated counterparts. The sample consisted of seven male and one female patient. They were mechanically ventilated for three days up to three weeks and length of stay varied from 21 to 28 days. Patients were interviewed individually and questioned about their memories six to 12 weeks after discharged from ICU.

The findings showed that many patients remembered being ventilated. Other memories were of relatives visiting, and details relating to the environment and staff. One patient expressed concerns at being suctioned:

"The suction part was very difficult. Unpleasant and sickening, and it also caused chest pain. At that point I thought I was being suffocated. Also changing from the respirator to my own breathing and then back again, it scared me to death, the fear of suffocating" (p.116).

Other experiences were also expressed, including dreams, nightmares, hallucinations and delusions. The authors suggested that such vivid memories might subsequently be a predictor of post-traumatic stress disorder.

In spite of these research findings, the importance of providing an appropriate explanation and skilled performance during suctioning is not new. Demers and Saklad (1973) recommended that the patient is informed of the procedure and any associated discomforts, in an attempt to reduce these disturbances. These recommendations were made more than thirty years ago, yet there is evidence to suggest that they are still not applied today (Sawyer 1997; Celik and Elbas 2000; Claesson et al. 2005).

Specific care should also be given to head injury patients, as the very act of suctioning has been associated with a reduction in partial pressure of oxygen (PaO2) and rise in partial pressure of carbon dioxide (PaCO2), resulting in cerebral vasodilation and an increase in intracranial pressure (Wainwright and Gould, 1996b). It is generally agreed that an appropriate explanation, along with adequate sedation and pain relief, can lead to a reduction in stress, anxiety and pain, and increase the effectiveness of the procedure in a more relaxed and co-operative patient (Peruzzi and Smith 1995; Wood 1998a).

Suctioning may frequently lead to hypoxaemia (Boutros 1970; Naigow and Powaser 1977; Adlkofer and Powaser 1978), which can cause cardiac dysrhythmias (Shim et al. 1969; Stone at al. 1991b), hypotension (Goodnough 1985) and even cardiac arrest and death (Marx et al. 1968). Suctioning has been shown to cause a fall in SaO2 levels by between 25% and 30%, with a slow rise to baseline over the following 3 minutes (Odell et al. 1993). During this period, there is an associated increase in oxygen consumption and a subsequent mismatch between supply and demand, resulting in a fall in SaO2 levels. In the critically ill, this may have detrimental effects, and Wainwright and Gould (1996a) suggest that nurses might adopt strategies to minimise these effects. These include hyperoxygenation through inspired oxygen, hyperventilation through an increased respiratory rate, or hyperinflation through an increased tidal volume. However, it should not be forgotten that some of these strategies may themselves be potentially hazardous. It is also important to acknowledge that, within the context of this study of ward nurses, some of these strategies are not appropriate.

3.2.2.2 Hyperoxygenation

Hyperoxygenation is the administration of oxygen at a greater percentage or fraction of inspired oxygen (FiO2) than the patient has been currently receiving (Glass and Grap 1995; Wood 1998a). This is usually performed immediately before the procedure but can also be during (insufflation) and/or after the procedure (post-oxygenation). According to Odell et al. (1993), suctioning has been shown to cause a decrease in SaO_2 by 25-30% followed by a slow rise back to baseline levels over a three-minute period. With open suctioning, oxygen consumption rises and there is a subsequent mismatch between supply and demand leading to fall in saturation levels (Walsh et al. 1989). A number of researchers have examined this issue and the literature dates back more than thirty years.

Harken (1975) studied the effectiveness of a 30 second period of preoxygenation, delivered by manual rebreath bag (MRB), on suctioning induced hypoxaemia in 11 post cardiothoracic surgical patients. The author reported no significant rise in arterial oxygen tension (PaO2) ($p > 0.05$). However, this was a small scale study and there were no reported measures of the patients' respiratory rate, FiO2 or tidal volume of the MRB intervention.

Adlekofer and Powaser (1978) investigated the effects of preoxygenation on hypoxaemia caused by endotracheal suctioning on 64 intensive care patients. From this sample, 54 patients received no preoxygenation and the remaining 10 were preoxygenated either by ventilator sigh mode, which delivers an increased tidal volume every 100 breaths, or via an MRB. The 54 patients who received no preoxygenation demonstrated a significant fall in PaO2 ($p < 0.001$). However, the group receiving either of the two interventions showed a non-significant change in PaO2 following endotracheal suctioning ($p > 0.05$). The authors concluded that widespread variation exists in PaO2 alterations and recommended that preoxygenation prior to endotracheal suctioning should be used for all patients. However, it is not clear from this study at what stage before suctioning the ventilator delivered the sigh breath, and tidal volumes delivered by MRB were not reported.

Belknap et al. (1980) examined the effectiveness of two modes of preoxygenation on 13 cardiac surgical patients; 100% oxygen delivered by a MRB, and the use of the ventilator sigh facility with no increase in FiO2. The patients received the relevant protocol and were suctioned once, with a gap of two to four hours between the interventions. The findings showed that although PaO_2 levels increased in those receiving 100% oxygen, there were no significant differences between the two protocols. Wainwright and Gould (1996a) stated that the authors "*go beyond their results by concluding that the MRB may be the preferred technique for preoxygenating patients with a low PaO2*". (page 391). Like the previous study, it is unclear at what stage the sigh facility was implemented and tidal volumes delivered by the MRB were unreported.

Lucke et al. (1982) carried out a similar study on 17 general ICU patients, and evaluated the effectiveness of two methods of preoxygenation; the use of 100% oxygen via the ventilator sigh mode or the MRB. The two methods were performed in random order before, during, and after suctioning, and the suctioning technique was identical for both groups. The results illustrated a significantly greater rise in PaO_2 and SaO_2 for those preoxygenated by the ventilatory sigh mode and the authors concluded that this method of preoxygenation was more effective than the MRB in controlling hypoxaemia in critically ill patients.

All of the earlier studies reviewed have involved the administration of 100% oxygen as a means of preoxygenating patients. Rogge et al. (1989) were the first to compare hyperoxygenation with 100% to hyperoxygenation with 20% above the patient's baseline FiO_2 in 11 patients with COPD. Four hyperinflations were delivered at 1.5 times the calculated tidal volume with either 100% or 20% above the baseline via a MRB. This was followed by 10 seconds of continuous endotracheal suctioning, and the sequence was repeated three times. No significant differences were found in SaO_2 levels between the two protocols ($p > 0.05$). The authors concluded that hyperoxygenation at 20% above the baseline FiO2 should be sufficient to prevent hypoxaemia, but recommended that the study should be replicated before implemented in practice. This would certainly benefit the patient with COPD because high oxygen concentrations might lower their PaO2 and reduce their hypoxic drive.

3.2.2.3 Hyperventilation

Hyperventilation is defined as an increase in respiratory rate. Downes et al. (1961) investigated the effects of hyperventilation with increased oxygen on preventing hypoxaemia in 11 patients during pulmonary resection. Prior to the study, the patients' lungs were continually hyperventilated. The trial itself consisted of two series; one was preceded by a period of no hyperventilation and apnoea for 1 minute with and without suctioning, the second involved hyperventilation with oxygen for 15 seconds, followed by apnoea for 1 and 2 minute periods prior to suctioning. One minute of apnoea resulted in an 8% fall in SaO_2 and hyperventilation with 15 seconds of oxygenation prior to suctioning resulted in a 2% rise in SaO_2. The authors concluded that a 15 second period of hyperventilation prior to apnoea, either with or without endotracheal suctioning, allows oxygen saturation to remain above safe levels. However, although the findings of this small-scale study do support those of other studies, the fact that 10 of the 11 subjects had pulmonary tuberculosis limits the ability to generalise these findings.

3.2.2.4 Hyperinflation

Hyperinflation is inflating the patient's lung to a greater volume than previously, with an associated increase in tidal volume (Wood 1998a). This is achieved by means of a MRB or an increased ventilator tidal volume (Marcinelli-Van Atta and Beck 1992; Wood 1998a; Robson 1998). Hyperinflation is known to increase residual capacity and reduce the incidence of atelectasis and shunting (Fiorentini 1992; Carroll 1994). However, the degree of hyperinflation above baseline tidal volume required to prevent a fall in arterial oxygenation remains unclear. Glass and Grap (1995) and Grap et al. (1994) suggest that hyperinflation should be 150% above the baseline tidal volume. However, Clapham et al. (1995) argued that this is difficult to achieve by MRB technique alone, and may also be a cause of discomfort to the patient. Moreover, large tidal volumes have been associated with barotrauma (Lookinland and Appel 1992), changes in mean arterial pressure and intrathoracic pressure (Carroll 1994), and reduced venous return, resulting in hypotension (Glass and Grap 1995).

Stone et al. (1989) studied the effects of hyperinflation on oxygenation and haemodynamics in eight post-cardiac surgical patients. The subjects were assigned at random to receive three hyperinflation breaths selected from one of five possible tidal volumes. Each hyperinflation breath was delivered at 100% oxygen and the series was followed by 10 seconds of endotracheal suctioning. PaO_2 levels remained above the baseline on every occasion, although no statistically significant changes in PaO_2, $PaCO_2$ or PH values were noted between the five different hyperinflation volumes. A significant increase in mean arterial pressure associated with each suction pass was noted ($p < 0.001$). However, no significant relationship was identified between the different volumes and this pressure increase ($p = 0.21$). Moreover, all subjects were reported to have coughed at some stage during the protocol (which normally occurs with suctioning), which may in itself have resulted in such changes.

Stone et al. (1991a) examined the effects of hyperinflation, delivered by a ventilator, on oxygenation and haemodynamic variables of 34 cardiac surgical patients. The subjects were assigned at random to receive three hyperinflation breaths selected from one of five possible tidal volumes. Significant changes in mean arterial pressure, pulmonary artery pressure and cardiac output were seen in all groups. A similar study by Stone et al. (1991b) showed an increase in mean arterial pressure with each hyperinflation sequence. The authors attributed this finding to an increased left ventricular preload and cardiac output, or a reduced left ventricular afterload. However, Wainwright and Gould (1996a) argued that this increase could be due to any rise in heart rate, caused by vagal stimulation during suctioning. Unfortunately, these data were not presented with the findings. Stone et al. (1991b) recommended that hyperinflation should not be used as a matter of routine practice. However, the study is limited by a small sample size and does not acknowledge that endotracheal suctioning alone can be the cause of such haemodynamic changes.

3.2.2.5 Hyperinflation and hyperoxygenation

The use of hyperinflation in conjunction with hyperoxygenation has been shown to cause the largest increase in arterial oxygenation. Goodnough (1985) investigated the effects of hyperoxygenation and hyperinflation on PaO_2 in 28 post operative cardiac surgical patients. The study compared four randomly assigned suctioning protocols, which varied in oxygen percentage (100% and baseline), and hyperventilation (via either the ventilator or MRB) before and after suctioning. All methods prevented a significant fall in PaO2 after suctioning, except for hyperinflation alone. Lookinland and Apel (1991) showed similar findings, and demonstrated that hyperinflation alone did not prevent hypoxaemia following endotracheal suctioning.

From the literature, it would appear that combining hyperoxygenation with hyperinflation at 150% of baseline tidal volume is one of the most effective methods of preventing suctioning induced hypoxaemia. However, there are major limitations to the use of hyperinflation via the MRB, which may lead to respiratory damage due to variable tidal volumes and airway pressures (Dam et al. 1994), barotrauma (Stone et al. 1991), and alterations in mean arterial pressure and cardiac output (Stone et al. 1991a,b; Singer et al. 1994). There is also evidence to suggest that hyperinflation is rarely achieved in clinical practice (Glass et al. 1993; Robson 1998). In their study of 100 nurses, Glass et al. (1993) found that only 30% were able to achieve the patient's current tidal volume, with an overall mean delivery of 17% lower than current tidal volumes. Robson (1998) argued that the question of "to bag or not to bag" has no clear answer, yet the technique continues to be widely used by physiotherapists who cite anecdotal evidence of its effectiveness (King and Morrell 1992). However, it is recommended by some authors that hyperinflation should be delivered by ventilator mode only (Glass et al. 1993; Grap et al. 1994; McKelvie 1998). Robson (1998) nevertheless suggested that until there is a definitive validation of the effectiveness of hyperinflation by MRB, it may be a useful technique for treating atelectasis, mobilising secretions and improving oxygenation, but recommends adequate training and the use of in circuit monitoring of tidal volumes, airway pressures and a Positive End Expiratory Pressure (PEEP) valve, if appropriate.

A number of questions arise from reviewing these studies. Although it is generally accepted that additional oxygen should be administered prior to suction to prevent hypoxaemia, the optimum method and time for preoxygenation are generally not known. The techniques and methods used and, indeed, the terminology used, have been inconsistent, and there are some discrepancies in the results (Fell and Cheney 1971; Lagnrehr et al. 1981). The small sample sizes of many studies and the use of the animal model makes it difficult to generalise findings.

In view of these issues, Hyunsoo and Whasook (2003) undertook a meta-analysis of various interventions to prevent suction-induced hypoxaemia. The purpose of the study was to clarify the effectiveness of interventions used to prevent hypoxaemia during suctioning. The selection criteria were for studies to have been published after 1970, an intervention to prevent hypoxaemia and involving only patients. Although there were thirty studies that satisfied these criteria, only 15 were included in the meta-analysis because of missing statistical data or inappropriate reporting of the data.

From each study, Hyunsoo and Whasook (2003) extracted variables including author, year of publication, diagnoses, sample size, method and times of oxygenation, method of suctioning, indices of hypoxaemia and statistical values. The magnitude and effect size of each study was calculated using Song's (1998) formula, a meta-analysis programme for testing the homogeneity of the effect size, and examining the statistical significance of the mean effect size (Hyunsoo and Whasook 2003).

The authors reported that the most prevalent intervention for oxygenation was to combine hyperoxygenation with hyperinflation and that these were introduced mainly by using an FiO_2 of 1.0 and a tidal volume of 150% for between three and six breaths. Insufflation was felt to be less effective than other methods. The authors concluded that the interventions used to prevent suction-induced hypoxaemia were sufficient, regardless of their times or methods.

This was a thorough analysis of the relevant research into hyperoxygenation and suctioning. Questions remain, however, around the most appropriate method in practice. In the ICU setting, combining hyperoxygenation with hyperinflation is often used and oxygen administered at an FiO_2 of 1.0 via the ventilator or a MRB. However, in the general ward setting, it is simply not possible to deliver an FiO_2 of 1.0 in a self-ventilating patient. The maximum possible FiO_2 is 0.6 using an humidified oxygen delivery system and, in the absence of training, nurses would not be expected to routinely use hyperinflation prior to suctioning. It is therefore recommended that hyperoxygenation using an FiO_2 of 0.6 (or 20% above baseline, in patients with COPD, Rogge et al. 1989) should be used in the ward setting.

Summary of recommendations:

From the literature reviewed, unless medically contraindicated, hyperoxygenation is recommended prior to tracheal suction. This should be 0.2 above baseline in patients with COPD or FiO2 0.6 in the self-ventilating patient. Patients receiving non-invasive ventilation (NIV) or continuous positive airway pressure (CPAP) can be hyperoxygenated with an FiO2 of 1.0. The method of achieving hyperoxygenation may vary from increasing oxygen levels via a tracheostomy mask to hyperinflation with a MRB, if adequate training has been received.

3.2.2.6 Normal saline instillation

The instillation of normal saline prior to suctioning has become common practice in many critical care units (Ackerman 1993; Ackermann et al. 1996). However, as Bostick and Wendelglass (1987) argued, this is an example of a widely practiced intervention that is not supported by research. In fact, there is considerable research evidence against its use (Blackwood 1999).

According to Ackerman (1993), the theoretical reason for instilling normal saline prior to suctioning is to loosen secretions. However, there is clear evidence that respiratory secretions and saline do not mix in vitro, and no evidence to indicate that they might mix in vivo (Demers and Saklad 1973). Hanley et al. (1978) instilled isotope-tagged 0.9% saline prior to suctioning and found that only 18.7% of the saline was removed. The remaining saline was shown by chest x-ray to remain in the trachea and bronchi, with none reaching the lung peripheries. In light of the empirical findings, questions are raised about the effectiveness of normal saline instillation. One theory is that it elicits a cough reflex (Gibbs et al. 1997). However, Gray et al. (1990) observed that a comparable cough could be stimulated by the suctioning procedure alone. Although some authors have continued to support the use of saline (Burton et al. 1984), this is not based on controlled research studies. Some authors have also suggested that the use of saline may cause a reduction in oxygen tension across the alveolar membrane, leading to hypoxaemia. However, research evidence is controversial.

Effects on oxygenation and heart rate

Bostick and Wendlegass (1987) investigated the effects of a 5ml or 10ml normal saline instillation on PaO_2 in 45 patients following cardiac surgery. Patients were randomly assigned to one of three groups; group I, a control (received standardised suctioning procedure without saline), group II, experimental (received standardised suctioning procedure with 5 ml normal saline instillation) and group III, experimental (received standardised suctioning procedure with 10 ml normal saline instillation). PaO_2 levels were analysed 5 minutes before and 20 minutes after suctioning. The findings showed no significant difference in PaO_2 ($p > 0.05$) either with or without normal saline. However, there was a trend towards lower post suctioning PaO_2 levels with the instillation of larger volumes of saline (i.e. 5 or 10 ml). Mean differences in PaO_2 for group I were 4.0 mmHg (0.53 kPa), 11.7 mmHg (1.56 kPa) for group II, and 13.5 mmHg (1.8 kPa) for group III. These differences, whilst not statistically significant, could have been clinically important, dependent on the patient's actual PaO_2 values. For example, in a patient who is already hypoxaemic, a fall in PaO_2 of 1.56 or 1.8 kPa might result in further clinical deterioration.

Bostick and Wendelgass (1987) suggested that normal saline instillation had no effect on oxygenation but recommended replication before firmer conclusions could be drawn. It is important to note, however, that there are methodological weaknesses in this study. Arterial blood gas samples were taken twenty minutes after the suctioning episode and it is possible that oxygenation levels had returned to pre-suctioning parameters during this period.

Similar findings were presented by Gray et al. (1990), who compared the physiological effects of suctioning with and without normal saline instillation. Subjects were initially suctioned without normal saline 90 minutes prior to the start of the study. Immediately prior to the next suctioning episode, they received three hyperoxygenation breaths (FiO2 1.0) and were suctioned again with a normal saline instillation (5 ml bolus). The final suctioning episode was 90 minutes later without the use of saline. The parameters measured included haemodynamic variables, respiratory rate, PaO_2, $PaCO_2$, pH, SaO_2, minute volume, Peak Inspiratory Pressures (PIP) and Forced Vital Capacity (FVC). Measurements were taken immediately prior to suction, immediately after suction and fifteen minutes after the procedure. Gray et al. (1990)

found that the material suctioned following saline appeared to weigh more than when saline was not used. However, as secretion weight was not measured, the validity of these findings is questionable. Gray et al. (1990) themselves recognised that due to the strong cough reflex elicited, perhaps not all patients received the same volume of normal saline. The authors concluded that the main advantage of normal saline instillation is its ability to stimulate a cough. The study also showed that there were no differences in respiratory mechanics (airway pressure or gas exchange) when using saline, which supports findings by Bostick and Wendlegass (1987). However, other researchers have shown conflicting results.

In their study of 26 critically ill patients, Ackerman and Gugerty (1990) studied the effects of normal saline instillation on oxygen saturation (SpO_2). SpO_2 levels fell significantly after suctioning, and those who had received a bolus of normal saline beforehand suffered a much greater fall in SpO_2. Similar results were presented by Ackerman (1990) in a study of 40 critically ill patients. Ackerman examined the effects of normal saline instillation on SpO_2 before and after suctioning. A fall in SpO_2 was seen in those who received the normal saline instillation. The authors expressed concern that the SpO_2 continued to fall over time, and reached their lowest levels five minutes post suctioning.

Ackerman (1993) and Ackerman and Mick (1998) have also examined the effect of normal saline on arterial oxygenation. In both of these studies, the use of normal saline was shown to have an adverse effect that became worse over time. In 1993, Ackerman examined the effects of saline instillation in 40 male mechanically ventilated patients. Subjects were randomly assigned to groups and were suctioned alternately using either saline (experimental) or no saline (control). Ackerman (1993) demonstrated that mean SaO_2 levels reduced over time. This ranged from 0.256 at 0 minutes, to 0.447 at 3 minutes and 0.701 at the five minute post-suctioning period. These differences were statistically significant ($p < 0.05$).

In 1998, Ackerman and Mick undertook a similar study on surgical and trauma patients with pulmonary infection. Patients were assigned to groups and were not hyperoxygenated prior to the procedure. The results showed a slight fall in SaO_2 for the saline group. This was statistically different ($p < 0.05$) to the control group at the four, five and ten minute assessments. However, the authors do not comment on the clinical significance of the decrease or whether any of the patient's SaO_2 levels fell to unacceptable parameters.

Ackerman and Mick (1998) also investigated the effects of normal saline on heart rate in these patients. The authors suggested that normal saline is a source of stress for patients, thereby resulting in an associated increase in heart rate. Increases were, however, small and did not reach significant levels ($p > 0.05$). However, Gray et al. (1990) presented conflicting results, with no differences in heart rate following normal saline instillation.

Akgul and Akyolcu (2002) undertook a study to determine the effects of normal saline on oxygenation, heart rate and long-term bronchial hygiene. Using an experimental design, the study included twenty mechanically ventilated patients who were admitted to ICU due to trauma, respiratory or cardiovascular problems. Oxygen saturation levels and heart rate were recorded one minute prior to suction and arterial blood gases were also taken. Each patient was suctioned twice, at two hourly intervals and according to hospital policy. Those who were suctioned without saline received a one-minute period of hyperoxygenation (FiO_2 1.0). Patients were then suctioned for 10 seconds with a size 14 Fr catheter. Those who received the normal saline were also hyperoxygenated (FiO_2 1.0) for one minute. This was followed by a 5 ml saline instillation. Patients were reconnected to the ventilator and given five mandatory breaths. Patients were then suctioned using a size 14 Fr catheter for 10 seconds. Findings from arterial blood gas analysis demonstrated significant decreases in PaO_2 ($p < 0.05$) 5 minutes after the procedure. This supports earlier findings by Bostick and Wendelgass (1987). However, when evaluating changes in HCO_3^- levels, there were no significant change in the values ($p > 0.05$). In patients where saline had not been given, there was a slight (but not significant) rise in the pH. However, five minutes after suctioning when using normal saline, the rise in pH was found to be statistically significant ($p < 0.05$). These finding support research by Gray et al. (1990). There were also changes in heart rate with patients receiving saline exhibiting increased heart rates four to five minutes after the suctioning episode ($p < 0.05$).

Effects on sputum weight

The effect of normal saline instillation on amount of sputum aspirated has also been investigated. Bostick and Wendelgass (1987) examined the impact of saline on sputum weight with and without saline instillation. The group who received the largest volume of saline (group III, 10 ml) had the highest amount of sputum weight when compared to the other groups. However, the amount of increase was small and not statistically significant. The authors state that definitive conclusions cannot be drawn from this study, as it was not possible to measure the precise percentage of normal saline mixed with secretions that were recovered on suctioning. In addition, the instillation of normal saline frequently stimulated a cough reflex, which, in itself, could have resulted in an increase in sputum weight. Similarly, Ackerman and Gugerty (1990) showed an increase in weight of sputum when normal saline was used, compared to when it was not. However, both authors state that the weight increases were small, and of neither statistical nor clinical significance. It is also important to note that assessing the weight of sputum can be unreliable, either with or without saline, as there are many factors that could influence how much sputum is aspirated on a single occasion. These include specific changes in the patient's condition, their position and ability to produce an effective cough.

Schreuder and Jones (2004) also investigated the effect of saline instillation on sputum yield and oxygen saturation in eight intubated patients. The patients received either saline instillation during five chest physiotherapy episodes (B phase) or no saline during physiotherapy (A Phase). The participants were subsequently randomised to ABA or BAB treatment phases. Oxygen saturations were recorded during and one hour after treatment and sputum was collected. The sputum yield was determined by wet weight of sputum and weight of sputum pellet after centrifugation. The results showed that all patients demonstrated a greater weight of centrifuged sputum after saline instillation. Visual analysis of the centrifuge lines showed a greater weight of sputum in five of the eight patients. No significant changes in oxygen saturation were observed during or following treatment. The authors concluded by stating that instillation of saline appeared to lead to increased wet and centrifuged weight of sputum. However, this study is presented as an abstract and it is not possible to analyse the data or establish how these conclusions were drawn. It is also not possible to establish how much of the saline was removed during suctioning.

Infection risks

Other detrimental effects of normal saline instillation include infection control issues and bacterial contamination. Rutala et al. (1984) studied the techniques used to instil normal saline in the intubated patient. Rutala and colleagues observed 24 nurses opening 92 normal saline vials, using an ungloved hand to twist or snap the top off the vial. The nurses were then asked to squirt 5 ml of the saline into a culture tube in the same manner in which they would instil normal saline into a patient's airway. The vials were examined at 24 and 48 hours, and the nurses were asked to simulate hand washing in a sterile bag for 15 seconds with a culture medium. The result showed that 23% of the vials were contaminated (the most prevalent bacteria being *Staphylococcus epidermidis*) and that 46% of the nurses had contaminated at least one of the vials during the study, which is a cause of concern about an intervention that could be considered routine practice for some practitioners. The authors concluded that effective hand washing and using a two-handed technique to open the vials might minimise the risks to the patient.

More recently, Hagler and Traver (1994) took ten endotracheal tubes from recently extubated patients to establish the infection risk associated with saline and suctioning. The protocol was to introduce a suction catheter into the endotracheal tube, allowing it to protrude by 5 cm. The protruding 5 cm was subsequently cut off and sent for culture. The suction catheter was removed and 5 ml saline instilled through the adaptor and a specimen jar at the distal end of the tube collected the saline, which was then sent for analysis. The length of time the endotracheal tubes had been in place varied from two to 39 days. The findings demonstrated that both suction catheter insertion and saline instillation dislodged bacteria in numbers that were significant. The authors report mean colony counts for catheter insertion as 10,460 (range <40 to 60,000) and 79,672 (range <40 to 310,000) for normal saline instillation. These results might indeed be significant for patients, although the clinical risk to patients is difficult to determine owing to the individuals immune defence mechanisms.

Effects on levels of dyspnoea

The use of saline prior to suctioning is also thought to lead to increased levels of dyspnoea. O'Neil et al. (2001) were the first to compare the level of dyspnoea with and without a 5 ml normal saline instillation in the ventilated patient. Seventeen alert but mechanically ventilated patients were asked to rank their level of dyspnoea using a visual analogue scale. Dyspnoea levels were ranked immediately after suctioning and at 10, 20 and 30-minute intervals. The level of dyspnoea between the groups was not significant ($p = 0.620$). However, significant differences were found ($p=0.034$) between the patient's ages, with older patients (greater than 60 years old) experiencing greater level of dyspnoea after saline than younger patients (less than 60 years old). The authors concluded that there are no benefits of using saline and that it might result in increased levels of dyspnoea for some patients. They recommended that the use of saline prior to suctioning should be avoided.

From the literature, there is no clear evidence to support the use of normal saline as an intervention prior to suctioning. Indeed, research reveals no clear benefit to the procedure and suggests that it may be potentially harmful in certain situations. Generally, no improvements in oxygenation or removal of secretions can be anticipated. Many authors now argue that if the premise of saline is to moisten thick secretions, attention should be diverted towards the humidification of inspired gases and systemic hydration of the patient (Ackerman 1993; Blackwood 1999).

Despite the lack of evidence, the instillation of normal saline prior to suctioning has become a common practice for many critical care units (Kinloch and Rock 1999). Schwenker et al. (1998) examined nurses and respiratory therapists practice regarding the use of saline and suctioning. This study took the form of a questionnaire survey, and findings indicated that of the 187 responses, (138 nurses and 49 therapists), 62 (33%) indicated that they used saline routinely. Although an unbalanced sample, there were significant differences between the two groups, with 64% of nurses stating that they rarely used saline and 71% of therapists reporting to frequently use saline. Reasons for using saline were reported as suctioning tenacious secretions, stimulating a cough reflex and to lubricate the suction catheter.

Sole et al. (2002) undertook a small-scale study to gather preliminary data and refine research instruments for a multi site study of suctioning techniques and airway management practices (STAMP). The aims of the STAMP project were to compare policies and procedures between institutions using closed suctioning systems, but they also examined practices including normal saline instillation and hyperoxygenation. A total of 132 practitioners took part in the survey, of which 75% were nurses (n = 95) and 28% respiratory therapists (n = 37). Staff members were asked how often they performed closed suctioning and other aspects of airway management. The findings showed that respiratory therapists used hyperoxygenation and normal saline instillation much more often than the nurses. Furthermore, most of the institutions in the survey reported that normal saline instillation is documented in their policy for clearing thick secretions and many staff (78% of respiratory therapists, 32% of nurses) reported that they almost always instil normal saline when suctioning.

Similar findings were seen in earlier work in the ICU setting, with 100% (n = 16) of nurses believing that saline should be used to loosen secretions. What is even more worrying is that most of these nurses (n = 11, 69%) were aware of the complications of saline. However, it was encouraging to note that none of the nurses in the ward setting used normal saline instillation in practice.

In reviewing these studies, a number of questions remain. In spite of the literature indicating that normal saline should not be used in practice, many individuals cite anecdotal evidence of its effectiveness. This was also apparent in the findings of an Intensive Care Conference in Berlin (European Society of Intensive Care Medicine, 2004), where a paper was presented about tracheal suctioning recommendations (Day 2004). During an interactive presentation using a *digivote* system, 49% (n = 73) of senior ICU practitioners (including doctors, nurses and physiotherapists from across Europe) reported that saline should be used prior to suctioning in order to loosen secretions or to stimulate a cough. Only 34% (n = 50) reported that saline should not be used before suctioning. As Sole et al. (2002) argued, it is now important to challenge these practitioners and investigate the reasons for their beliefs and for practicing against current research recommendations.

<u>Summary of recommendations:</u>

From the literature reviewed, in the absence of more conclusive data, the use of saline prior to suctioning should be avoided. The only rationale for using saline would be to instigate a cough, whereby a skilled practitioner could instil a small amount of saline (i.e. 1 to 2 ml) for this purpose.

3.2.2.7 Infection control measures

Tracheal suctioning is an invasive procedure and is therefore associated with an increased risk of infection (Pierce 1995). Both tracheal and endotracheal intubation prevent an effective cough as the glottis remains open, which limits the clearance of secretions and promotes pooling at or near the end of the artificial airway (Judson and Sahn 1994; Chatila et al. 1995). The tube itself can act as an irritant, leading to inflammation and impaired mucociliary function. All of these factors have been shown to lead to an increased risk of infection in a debilitated and immunocompromised patient (Judson and Sahn 1994; Wood 1998a). There is little argument that aseptic suctioning should be mandatory in all patients (Demers and Saklad 1973; Demers 1982; Odell et al. 1993; Luce et al. 1993; Dean 1997). However, there are considerable variations of how this is implemented in practice, which range from the use of non-sterile gloves (using a non-touch suctioning technique) to sterile gloves (Parker 1999a).

The closed method of suctioning has been shown to reduce the risk of nosocomial infection as this technique avoids opening the airway to contamination. Closed systems also limit exposure of the surrounding area to contamination, thereby protecting others from infection. As there is no interruption to ventilation or oxygenation during suctioning, they can also reduce the risk of hypoxaemia. However, as this study is confined to the acute and high dependency setting, closed systems are not applicable and cannot be used in a self-ventilating patient. Some authors even have suggested that sputum removal is ineffective using closed systems (Blackwood 1998). Variations in using this technique have also been reported in practice (Sole et al. 2002).

No studies, on current literature searching, have examined whether sterile or non-sterile gloves, or even a double-gloved technique is more likely to reduce the risk of infection. Little (1998) and Parker (1999a,b) both argue that the importance of hand hygiene and the use of protective gloves cannot be over emphasised. Brooks et al. (1999) undertook a survey examining suctioning techniques and reported that glove practices varied from the use of non-sterile gloves to two sterile gloves. Surprisingly, 2.8% of subjects (n = 7) stated that they did not wear gloves for suctioning. May

(2000) argued that infection control is an issue that affects everybody and that it should underpin every aspect of healthcare.

It is important to remember that gloves do not replace the need for hand washing, as hands should be washed before and after the procedure (Parker 1999a). Parker (1999a) suggested that hand washing occurs approximately half as often as it should and for a shorter duration than recommended. In one study, none of the nurses were observed washing their hands before suctioning (Celik and Elbas 2000). Similar findings were seen in previous work in both the ICU and ward setting, as few nurses washed their hands before or after the procedure.

A number of authors recommend that universal precautions should be implemented, which includes the use of aprons and goggles during open suctioning in order to minimise the infection risks to the practitioner (Little 1998; Wood 1998a). Protective eye wear is especially important, as the eye itself and surrounding delicate mucous membranes are very vascular. Any splashes of infective sputum could pose a serious infection control threat to the practitioner who is performing the procedure.

Summary of recommendations:

Effective hand hygiene, both before and after suction, is an essential recommendation. Gloves may be either sterile or non-sterile, according to local policy, but a non-touch technique should be employed. It is also essential to wear an apron and use protective eye wear in the form of goggles.

3.2.3 Suctioning

For some aspects of suctioning, it is important to note that recommendations are based on lower levels of evidence where randomised control trials do not exist.

3.2.3.1 Catheter selection

Suction catheters are manufactured in polyvinyl chloride and do not normally require lubrication (Pierce 1995). A variety of catheters are currently available, and there is some evidence to suggest that those with a single side hole may produce more damage than catheters with multiple side holes (Sackner et al. 1973; Link et al. 1976; Young 1984). This is due to an increased risk of occlusion of both holes, resulting in maximum pressure build up on the tracheobronchial mucosa.

Larger size catheters have been shown to increase the risk of trauma due to greater mucosal contact (Young 1984). It is widely accepted that the external diameter of the suction catheter should not exceed one half of the internal diameter of the tracheal tube (Odell et al. 1993; Glass and Grap 1995; Wood 1998a). This allows air to enter the lungs whilst oxygen is being removed during suctioning, which guards against excessive negative pressures and potential atelectasis. Adult size endotracheal and tracheostomy tubes range from 30 to 38 French Gage (FG), or 7 to 9 millimetres (mm), and suction catheters from 8 to 16 FG, or 2 to 2.5 mm. Odell et al. (1993) recommend that the formula: size of endotracheal tube -2 x 2 equals the maximum size suction catheter to use. However, it is important to note that very small suction catheters (size 8) are not always available in adult settings and the minimum size recommended is size 10.

Summary of recommendations:
The recommended formula for calculating the size of suction catheter is size of tracheostomy tube – 2 x 2. An alternative formula of size of tube x 2 – 4 has also been put forward and both should come up with the appropriate size.

3.2.3.2 Depth of insertion

Stimulation of the vagus nerve during suctioning may result in alterations in the patient's heart rate and blood pressure, resulting in bradycardia and hypotension. Prolonged paroxysmal coughing will result in increased intrathoracic pressure, decreased venous return and transient hypotension (Wood 1998a). Griggs (1998) suggested that, a few days after tracheostomy formation, many patients are able to cough secretions to the end of the tracheostomy tube and the suction catheter need only be inserted just beyond this, thus reducing pain and trauma (Ashurst 1992). However, in sedated or paralysed patients, it may be necessary to advance the catheter beyond this, but this will increase the likelihood of entering the right main bronchus and reduce the effectiveness of sputum removal (Ashurst 1992). Pierce (1995), Dean

(1997), and Wood, (1998a) all recommend inserting the catheter fully to the carina, which is either felt by resistance or on stimulation of a cough, then withdrawing the catheter 1 cm prior to the application of suction.

Summary of recommendations:

The suction catheter should be advanced to the carina, and the catheter withdrawn by 1 cm before suction pressure is applied.

3.2.3.3 Negative pressure

Application of negative pressure during suctioning may cause trauma to the mucosa as it becomes invaginated through the eyes of the suction catheter (Czarnik et al. 1991). Significant tracheal damage, ulceration and necrosis were found in an animal study. Czarnik et al. (1991) examined the effects of continuous versus intermittent suctioning on tracheal tissue in 12 mongrel dogs. The dogs were assigned at random to one of two experimental groups (group 1 received continuous suction, group 2 intermittent suction), with a control group of two animals, who were not suctioned. The results showed significant tracheal damage, ulceration and necrosis in both experimental groups for both continuous and intermittent suctioning. However, Czarnik et al. (1991) used excessive suction pressures of 200mmHg, which may have contributed to these findings. Using high negative pressures does not mean that more secretions will be aspirated, so limiting pressures to between 80 and 150mmHg (11 and 20 kPa) is recommended (Luce et al. 1993; Boggs 1993).

Within the literature, there is debate as to whether suctioning should be continuous or intermittent (Flunck 1985; Czarnik et al. 1991). Catheter design and suctioning pressures have been the main variables under investigation. The study by Czarnik et al. (1991) is based on the animal model and is not directly applicable to humans. Nevertheless, despite these issues, there are a number of advantages to continuous suctioning. It helps to prevent loss of mucous plugs and is more effective in removing secretions (Luce et al. 1993; Thelan 1994).

Wood (1998a) argued that continuous suctioning also reduces the risk of hypoxaemia and mucosal damage because the secretions removed fill the suction catheter and reduce the amount of suction applied to the tracheal wall. However, continuous suction increases the risk of atelectasis. Glass and Grap (1995) advocate the use of continuous suctioning on catheter removal as there is no evidence to suggest that intermittent suctioning reduces trauma, and at least one study that has identified it as ineffective (Luce et al. 1993; Thelan 1994). Similarly, rotation of the catheter during withdrawal has not been associated with significant increases in sputum removal, and may in fact contribute to further trauma (Glass and Grap 1995).

Despite this evidence, practitioners continue to use high suctioning pressures. Owing to a lack of available equipment and a machine that was unable to deliver lower pressures, Celik and Elbas (2000) reported that the patients in their study were suctioned using a suction machine that delivered a *minimum* negative pressure of 300mmHg (40kPa). This is twice the recommended pressure and could have compromised patient safety. This study also found that 82.6% of suction passes (n = 90) involved suctioning being applied during catheter insertion. In relation to safe suctioning pressures, similar findings are presented in earlier research findings. In the ICU setting, the majority of nurses (n = 14, 87.5%) used suctioning pressures of 150-199mmHg (20-26 kPa), which are higher than recommended. Similary, in the ward setting, most (n = 26, 93%) used the same high pressures, with many nurses failing to distinguish between set and applied pressure.

Donald et al. (2000) tried to establish whether an in-circuit monitoring device to measure suctioning pressures would influence negative pressures. The findings showed that negative pressures were significantly higher (mean applied pressure of 359.5 mmHg, 48 kPa) than recommended as safe in the literature. This study demonstrated that the presence of a visible manometer did not prove to be an adequate way of ensuring the use of safe suctioning pressures. However, this study was designed as a role-play simulation in a physiotherapy department and did not involve patients. In view of these findings, questions arise as to why practitioners are using such high negative pressures during suctioning, and practitioners should perhaps be challenged about these aspects of their practice.

Summary of recommendations:

Suction pressures should be no higher than 20 kPa. Pressure should be applied on catheter withdrawal only and the technique should be continuous with no lateral movement.

3.2.3.4 Duration of procedure

The majority of authors recommend that suctioning should take between 10 to 15 seconds to perform, as longer durations are associated with an increased risk of mucosal damage and hypoxaemia (Boggs 1993; Odell et al. 1993; Smith 1993). However, there are no empirical studies on which to base this recommendation. Anecdotal information suggests that the practitioner should hold their breath at the start of the procedure. When the practitioner needs to take the next breath, this should be the maximum duration from insertion to removal of the suction catheter. However, there are important issues to consider here, since most patients with trachesotomies requiring suctioning have some form of altered pathology, making this difficult. It is also difficult to complete the suctioning episode within this time frame. In earlier research, all ICU nurses (n = 16, 100%) took longer than 15 seconds to complete each suction pass.

Summary of recommendations:

The complete suctioning procedure (i.e. from disconnection of oxygen to reconnection) should take no longer than 15 seconds to perform.

3.2.3.5 Number of suction passes

Wood (1998a) argued that an additional variable that may contribute to the occurrence of complications is the number of suction passes in one suctioning event, as it maybe necessary to use more than one suction pass if there are copious amounts of secretions. Some authors recommend allowing the SpO2 to return to pre-suctioning parameters before another suction pass is attempted (Smith 1993), which Pierce (1995) argues should be no less than 30 seconds. However, the majority of researchers advocate that, unless the patient is in respiratory distress, no more than three suction passes should be made per episode and that the number of passes should be kept to a minimum (Fiorentini 1992; Glass and Grap 1995).

Monitoring the patient's heart rate and rhythm, arterial blood pressure and SpO2 during the suctioning procedure is also recommended. Suctioning should cease and hyperoxygenation should be initiated immediately if any untoward complications are observed (Glass and Grap 1995; Wood 1998a).

Summary of recommendations:

No more than three suction passes should be made on any one occasion and the patient's colour, heart rate and oxygen saturation should be monitored during the procedure.

3.2.4 Post Suctioning

Within the literature, there is very little reference to the priorities that should be undertaken following the suctioning procedure. However, in spite of the lack of empirical data, there is little doubt that these are important issues that influence the process of suctioning as a whole. Exploring practice by considering the various components of suctioning individually could be seen as reductionism and for these reasons, a more holistic view of the whole process was felt to be fundamentally important. This is the first study to consider these post-suctioning events. These include reconnecting the patient to the ventilator or oxygen supply within a maximum period of 10 seconds (Adam and Osborne 2000), monitoring the patient's heart rate, SpO2 and colour during and following the procedure (AARC 1993), and a thorough respiratory assessment (Glass and Grap 1995; Day 2000). It is also important to reduce oxygen to pre-suctioning parameters, to observe sputum for colour and consistency and to document findings appropriately.

3.2.5 Synthesis of research recommendation

Table 3.2: Summary of recommended practice

Action	**Recommended Practice**
Prior to suctioning	
Assessment	Undertake a comprehensive respiratory assessment, including chest auscultation (Glass and Grap 1995; Griggs 1998).
Patient Preparation	Provide an appropriate explanation along with adequate sedation and pain relief (if appropriate) in order to reducte stress, anxiety and pain, and increase the effectiveness of the suctioning procedure (Peruzzi and Smith 1995; Wood 1998a).
Pre-oxygenation	Pre-oxygenate prior to suction (Wainwright and Gould 1996) in order to reduce the risk of hypoxaemia (Adlkofer and Powaser 1978), which can cause cardiac dysrhythmias (Stone at al. 1991b), hypotension (Goodnough 1985) and even cardiac arrest and death (Wood 1998a).
Infection control	It is recommended that hands should be washed before and after suctioning and that aprons gloves and goggles should be worn during suctioning (Wood 1998a; Parker 1999a; Parker 1999b; Pratt et al. 2001) in order to reduce the risk of infection.
Suctioning	
Catheter selection	The recommended formula to calculate the maximum size suction catheter to use is: **Size of endotracheal/tracheostomy tube –2 x 2** (Odell et al. 1993). Larger suction catheters have been shown to cause trauma, due to greater mucosal contact (Young 1984) whereas smaller catheter may be ineffective at removing secretions.
Depth of catheter insertion	Suction catheters should be fully inserted to the carina and then withdrawn 1cm before suction is applied (Dean 1997 and Wood 1998a). However, for those patients able to cough this may not be necessary (Griggs 1998).
Negative pressure	Applied negative pressure should be between 80 and 150mmHg or 10.6-20kpa (Luce et al. 1993 and Boggs 1993). Higher pressures have been shown to cause trauma, hypoxaemia and atelectasis (Czarnik et al. 1991). To prevent the suction catheter from adhering to the tracheal mucosa negative pressure should only be applied during withdrawal (Glass and Grap 1995). Suction pressure should be applied continuously as opposed to intermittent (Glass and Grap 1995).
Duration of suction	Suctioning should take between 10 and 15 seconds to perform as longer durations are associated with an increased risk of hypoxaemia and trauma (Boggs 1993).
Number of suction passes	No more than three suction passes should be made during any one suction episode (Glass and Grap 1995) as an increased number of suction passes may contribute to the occurrence of complications (Wood 1998a).
Post suctioning	
Reconnection to oxygen therapy	Reconnect the patient to oxygen within 10 seconds post suctioning (Day 2000; Adam and Osbourne 1997) in order to minimise the risk of hypoxaemia.
Assessment	Undertake a thorough assessment of the patient post suctioning, including chest auscultation (Glass and Grap 1995; Day 2000), to determine the effectiveness of the suctioning procedure,
Reduction of stress and anxiety	Provide verbal reassurance to the patient after suctioning in order to minimise stress and anxiety cause by the procedure.
Reduction of oxygen	Reduce the level of inspired oxygen to pre-suctioning parameters (Pierce 1995) in order to prevent oxygen toxicity and adhere to prescription.
Hand washing	Wash hands after the suction episode in order to prevent cross infection (Parker 1999b).

An overall synthesis of the research recommendations is presented in Table 3.2. These recommendations informed the development of the research instruments and subsequently the best practice recommendations. The content of the standardised teaching programme followed the format of prior to, during and post suctioning and, in an attempt to promote knowledge and skills retention, the performance feedback sheet was structured so that feedback could be given the same way.

3.3 Implications of the literature on the present study

The literature has highlighted some important issues for all aspects of tracheal suctioning. Patients with tracheostomies may require suctioning on a regular basis, and the responsibility for this intervention rests with either the nurse caring for that patient or the physiotherapist initiating treatment. Any knowledge deficits might result in poor practice and potentially dangerous suctioning techniques, which could prove detrimental to the patient. In order to be accountable in performing this skill, it is essential for registered nurses and chartered physiotherapists to be aware of the complications and potential hazards of suctioning, and to be able to implement safer suctioning techniques. However, from the literature reviewed and previous research findings, it is hypothesised that practitioners may be unaware of current recommendations and practice might be based on ritual and tradition as opposed to empirical evidence (Tanser et al 1997; Brooks et al 1999).

CHAPTER FOUR: EDUCATIONAL INTERVENTIONS

4.1 Introduction

From the literature reviewed, there is increasing evidence that one-off educational interventions result in only short term improvements in knowledge and skills and do little to ensure that knowledge is enacted in practice. Bero et al. (1998) identified a number of specific interventions that were more likely to consistently promote behavioural change. These included educational outreach visits, reminders and what they referred to as "multifaceted" educational interventions. Bero et al. (1998) described multifaceted interventions as a combination of audit and performance feedback, reminders, local consensus processes and marketing. Wensing and Grol (1994) recommended that studies employing such a framework should include two or more of these strategies. The studies on hand washing mostly concluded that interventions which included tailored feedback were more likely to have a positive impact on performance over time (Conly et al. 1989; Berg et al. 1995; Dorsey et al. 1996; Larson et al. 1997; Pittet et al. 2000). Only one study considered this framework ineffective (Simmons et al. 1990).

Performance feedback is defined as a provision of a summary of overall clinical performance. Wensing and Grol (1994) suggested that feedback can be both visual as well as verbal and could even take the form of a poster. Providing practitioners with personalised feedback might also overcome the well-documented problems of sustaining knowledge and skills over time (Corner and Wilson-Barnett 1992; Mosler and Coleman 1992) and the potential discrepancies between knowledge and practice (Rolfe 1998). These problems were encountered in earlier research in the ICU setting, as a number of participants' knowledge and practice scores had deteriorated over time. It was recommended that further assessments of knowledge and practice at three monthly intervals, together with individual performance feedback, would enable these issues to be more closely examined. On the basis of these recommendations, an experimental intervention was developed and this study was designed to evaluate the effectiveness of a performance feedback framework on nurses and physiotherapist's tracheal suctioning practices.

This chapter presents the features of the standardised intervention. This took the form of a conventional teaching programme. This chapter also discusses the salient features of the individualised performance feedback, which was the main framework that underpinned this study.

4.2 Standard intervention

4.2.1 Conventional teaching programme

The standard intervention consisted of a conventional teaching programme, which was developed for the intervention and control groups (Appendix 11). The purpose was to create a level field, so that all participants would commence the study having received the same input about tracheal suctioning. Information obtained from previous research has highlighted a tendency for tracheal suctioning education to be very "ad hoc" across educational programmes, with some practitioners being taught how to suction during pre and post registration courses and others receiving no teaching at all.

The conventional teaching programme consisted of a one hour session on tracheal suctioning and took place in a seminar room attached to the ward or department. The session took the form of a lecturer-led session with a practical demonstration. Both nurses and physiotherapists were invited to attend the session, which took place prior to the randomisation process.

The format for teaching remained identical for each session so that all participants would receive the same amount of educational input. For each session a detailed plan, learning outcomes and practice outcomes were identified (Appendix 11). The content of the session was designed according to the necessary actions to be taken prior to suctioning, during suctioning and post-suctioning, thus following the same themes as the literature.

The best available research evidence (Appendix 12) formed an integral part of the session and sources of evidence were available, both visually and verbally. The learning outcomes related to the overall objectives of the session and the practice outcomes the desired effects on performance. A variety of teaching methods were utilised, including both didactic and interactive approaches, and a practical demonstration. An identical mannequin was used for demonstration purposes on each of the study sites. The features of the session are shown in Table 4.1

Table 4.1: Features of the conventional teaching programme

Teaching Methods	Content
Didactic presentation (verbal exposition)	Rationale and indications for suctioning Events prior to suctioning: hyperoxygenation, infection control measures
Interactive discussion	Normal saline instillation
Didactic presentation	During suctioning: catheter selection, negative pressures, technique, duration Post suctioning
Practical demonstration	The complete suctioning procedure

The session was delivered verbally with the aid of a *Powerpoint* presentation (Appendix 13). Best practice recommendations were also discussed and distributed to participants during the sessions (Appendix 12). Participants were asked not to leave these recommendations unattended, which were watermarked with "do not copy". It was initially envisaged that four sessions per research setting would be offered, with up to thirty places. However, due to practicalities and staffing levels this was not possible and, in the end, there were around eight sessions on each site. One feature of the teaching session was the make up of the group, as it was considered desirable for both professional groups to be taught together. This was primarily to encourage discussion between the two professions, as anecdotal and empirical information (Brooks et al. 1999) has indicated that practices do vary, and one group already consider themselves experts in this field. It was hoped that the interactive sessions might promote better communication. However, it was acknowledged that on some occasions this might not always be possible, which was not especially problematic as the learning and practice outcomes were the same for each profession.

The teaching strategies were organised to incorporate a variety of activity based exercises and lecturer led information. The session began with an activity, as participants completed the questionnaire. This was followed by twenty minutes of lecturer-led verbal exposition, and subsequently a discussion about normal saline instillation. The suction technique was demonstrated and the participants gathered round to observe best practice. Questions were invited as the session was drawn to a close.

During the session and immediately prior to teaching, the participants were asked to complete the knowledge-based questionnaire. It was envisaged that the questionnaire would take no more than fifteen minutes to complete, based on pilot work and previous research, and this was incorporated within the time frame.

4.3 Experimental intervention

4.3.1 Performance feedback framework

The experimental intervention examined in this study was the addition of structured feedback on performance. This was given between six and ten weeks after the conventional teaching. The aim of this was to reinforce the prior learning and to assist in its retention over time. The feedback took the form of a written performance feedback booklet (see additional material under separate cover). This was structured around the same elements of prior to suctioning, during suctioning and post suctioning. Conventional teaching had been organised around these three key areas and it was anticipated that this would assist memory. These three areas were also colour coded, as recommended by others (Dorsey at al. 1996; Tibbals et al. 1996; Pittet et al. 2000) in a further attempt to assist memory. The participants were given detailed information about their questionnaire responses, including the actual scores prior to and following initial teaching. For each individual element of the suctioning procedure, boxes were ticked to indicate how the participants had performed in practice, and how this either complied or did not comply with research recommendations. The appropriate responses were highlighted on the performance feedback sheets and participants were reminded of research recommendations.

Performance feedback consisted of a visit to the workplace. Feedback was managed by a researcher visiting each participant in their respective clinical areas. The researcher was unconnected to that study site and not involved with data collection.

The visit took the form of a one-to-one meeting in a private room. Arrangements about possible feedback dates were made in advance by telephone to ensure that it was convenient for the participants. During the visit, each participant was verbally reminded about all aspects of the suctioning procedure. It was emphasised that the performance feedback related to that individual's performance only and not general aspects of the study.

4.4 Chapter summary

This chapter has described the details of the standardised educational intervention, the purpose of which was primarily to ensure that all participants would commence the study having received the same amount of input about tracheal suctioning. This chapter has also outlined the salient features of the tailored performance feedback, which was the main framework that underpinned the study.

CHAPTER FIVE: METHOD

5.1 Introduction

The study was designed as a two-centre experiment and took place over two large inner London NHS Trusts. The sample size was 95 and consisted of registered nurses and chartered physiotherapists. At initial baseline level, a standardised, conventional teaching programme about tracheal suctioning was developed for both an interventional and control group, based around current best evidence, supported by literature. This took place over a one-hour period and was delivered in a practice environment by a conventional lecture and practical demonstration. The participants were subsequently observed in practice and completed a knowledge-based questionnaire. On one of the sites, practice was observed in the clinical setting using patients; on the other site the observations took place in the same settings but using simulation. The interventional arm of the study subsequently received additional education, in the form of individual performance feedback. The feedback took the form of written material and was tailored around knowledge and practice scores and any omissions or areas for improvement. Observational and questionnaire data were collected again four months after initial teaching.

5.2 Aims and objectives

5.2.1 Aim

The overall aim of the study was to determine whether individualised performance feedback improved nurses' and physiotherapists' knowledge and practice of tracheal suctioning.

5.2.2 Objectives

The objectives of the study were:

1. To determine nurses' and physiotherapists' knowledge of tracheal suctioning after conventional teaching.

2. To determine nurses' and physiotherapists practice of tracheal suctioning after conventional teaching.

3. To investigate the effect of individual performance feedback on the retention of knowledge and practice over time

4. To determine whether providing performance feedback in a simulation setting has the same effect as feedback in a clinical setting.

In order to address these aims and objectives, the following experimental hypotheses were formulated. Nurses and physiotherapists are collectively referred to as "practitioners".

5.2.3 Experimental Hypotheses

1. The practitioners who receive a conventional teaching programme will demonstrate a higher level of knowledge than at baseline level.

2. The practitioners who receive individual performance feedback will sustain a higher level of knowledge and practice four months after the conventional teaching programme compared to those who do not receive feedback.

3. The practitioners who receive individual performance feedback demonstrate a closer correspondence between knowledge and practice compared to those who do not receive feedback.

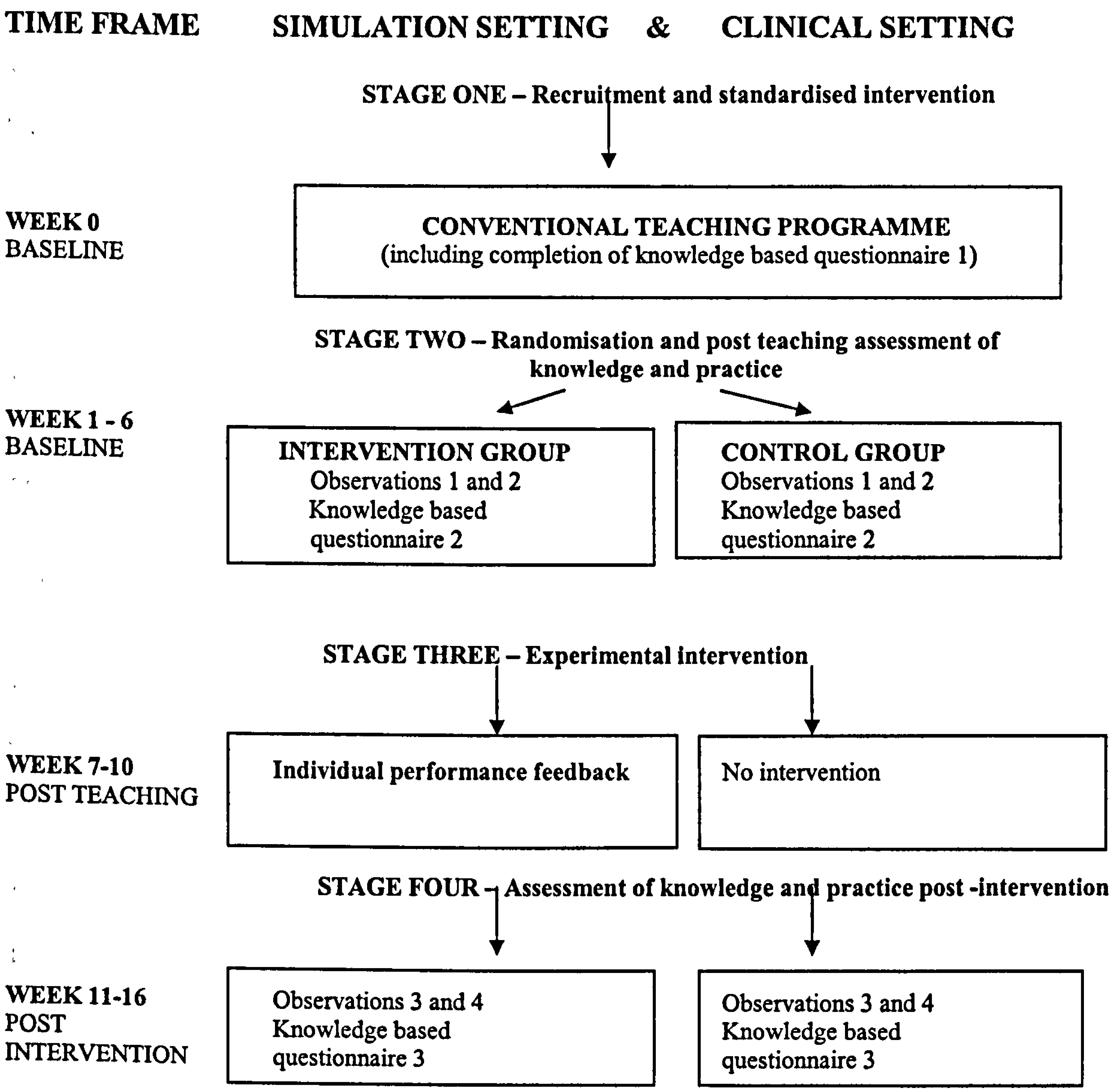
4. There will be no difference in knowledge and skills between practitioners who were observed using simulation when compared to those observed in practice.

5.3 Design and methods

5.3.1 The randomised control trial

The study design was a randomised control trial (RCT) comparing outcomes for an intervention group, who received a conventional teaching programme plus individual performance feedback, with a control group, who received a conventional teaching programme only. Knowledge was assessed prior to teaching, within six weeks of teaching and again following performance feedback. The participants were observed at two points; following conventional teaching and again following performance feedback. For the control group, data were collected within the same timeframe, but this group received no performance feedback. A flow diagram to illustrate the design is presented in Figure 5.1. The design was identical for the both settings.

Figure 5.1 Flow diagram to illustrate design



The RCT is considered to be the most rigorous way of determining a relationship between cause and effect and assessing/evaluating the effectiveness of an intervention on outcome (Hsu 1989; Getliffe 1998; Sibbald and Roland 1998). It is useful for establishing a relationship between cause and effect, as it enables similar subjects to be allocated into groups and specific variables manipulated in order to demonstrate a direct effect (Wilson-Barnett 1991). However, there are potential sources of bias, which can prove challenging to the researcher (Wilson-Barnett 1991; Steward and Parmer 1996).

Internal validity is the degree to which it can be inferred that the experimental intervention is responsible for the observed effects on outcome, as opposed to extraneous variables (Polit and Hungler 1995). Campbell and Stanley (1966) summarised eight threats to internal validity. In a true experimental design, these threats should all be controlled for. With the exception of Campbell and Stanley's first point, which was unable to be fully controlled, this study attempted to address the remaining threats to internal validity, as shown in Table 5.1.

External validity is the ability to generalise findings to the wider population. Wilson-Barnett (1991) argued that external validity, whilst desirable, is often limited. Threats to external validity relate to the artificial nature of the research environment. In this study, an artificial environment did not pose a problem in the clinical setting, as the participants were observed in their own work surroundings. However, the simulation setting was purposefully artificial. Attempts were made to make the simulation setting seem as realistic as possible by setting up a bed space with all of the available suctioning equipment, simulation mannequins and oxygen therapy. Patient scenarios were also produced to help set the context of the suctioning episode for the individual "patient".

Another major challenge was the risk of contamination of the intervention, with aspects of the observation and feedback affecting members of the control group. Indeed some of the participants in the intervention group could have discussed the study with those in the control group. Randomising the wards, as opposed to the individual subjects to groups, might have been a way around this. However, as there were so few wards available to participate in the study, this was not an option. Furthermore, whilst the nurses were assigned to a specific ward, the physiotherapists were not, as their practice spanned many different wards and departments. An important point to note here is that the potential adverse effects of contamination were limited, as the feedback on performance was tailored to the individual. However, subjects were asked not to discuss details of their feedback with others, and the names of participants were not disclosed.

Table 5.1 Actions taken to reduce threats to internal validity

Threat to interval validity	Description	Action taken
History	The influence of extraneous variables on the outcome of a study, such as publications about suctioning.	This was outside of the researcher's control, but would have affected both the experimental and control groups.
Maturation	Maturation of subjects over the duration of the study, enabling the researcher to be unsure about which had had an effect on the dependent variable.	This was unlikely to have been a problem as the study took place over four months, a relatively short period of time.
Testing	The effects of pre-test results on post-test results.	This could have been a problem as the same questionnaire was completed before and after teaching. However, this was intentional.
Instrumentation	Validity and reliability of research instruments.	Expert validation of instruments prior to use. Each tool was piloted more than once and tested for inter-rater reliability.
Statistical regression	This can occur if subjects have a "bad" day, leading to a shift in mean scores.	The strategy adopted was to observe each participant performing two suction passes at each stage of data collection.
Selection biases	This can occur if subjects are not randomly assigned resulting in non-equivalent groups.	Participants were randomly assigned to groups although due to numbers available to participate, these were not equivalent.
Mortality	Loss of subjects and sample attrition may pose a threat.	Only a few participants were lost during the study.
Selection-maturation interaction	This occurs in unequal groups when the passage of time affects one group only.	The design of the study incorporated an identical time frame for both groups.

5.3.2 The knowledge based questionnaire

A knowledge based questionnaire was considered the most appropriate method of assessing knowledge (Appendix 9). Polit and Hungler (1995) remind us that although this is a powerful mechanism for collecting data, there is always the potential for response bias, as the respondent could distort their responses in order to present a more positive image of themselves. This is more likely to occur in research exploring attitudes and opinions as opposed to knowledge. With a knowledge-based questionnaire, this is unlikely to occur if the "correct" response is not known, although there is always the risk of participants guessing the answer.

Specific information to be sought was identified from the literature and the study aims and hypotheses. The decision to use a self-completion questionnaire, to be completed in the presence of the researcher, was to minimise the risk of contamination. Postal questionnaires might have enabled participants to discuss their responses with other colleagues, which would have invalidated any baseline or subsequent knowledge assessments. Question content was organised into three categories; demographic details, rationale for suctioning and the process of suctioning. The process of suctioning was arranged according to events prior to, during and post-suctioning, thus following an identical format to the literature, and focused on the elements listed in Table 5.2

Table 5.2 Contents of the questionnaire

Questionnaire section	Content
Section A: Demographic details	Grade, age, gender, experience, courses completed
Section B: Rationale for suctioning	Indications for suctioning
Section C: Prior to suctioning	Patient preparation Reducing the risk of hypoxaemia Normal saline instillation Infection control measures
Section C: Suctioning	Catheter selection Negative suction pressures Depth of insertion Suction technique Duration of procedure Number of suction passes
Section C: Post-suctioning	Reconnection to oxygen/ventilation Reduce FiO2 to pre-suctioning parameters Assessment of the patient Providing reassurance Documentation of findings

Closed-questions were used where factual information with set responses was sought, as recommended by McColl (1993) and Parahoo (1993). However, for certain aspects it was felt that closed questions would potentially lead the respondent to the correct response, and an open-ended question was formulated. For example, had the questionnaire featured closed questions for infection control practice, the likelihood is that these would have been automatically completed. By being prompted about hand washing, few respondents would not complete this question. Formulating an open question and asking for important infection control practices was less likely to lead the respondent to an obvious answer.

The wording of each question was carefully phrased in clear and concise language, in order to avoid any ambiguity. Questions were formulated in language that was familiar to nurses and physiotherapists working within the acute care setting. Lengthy questions were avoided. Demographic details, according to Cormack (1996), may appear either first or last on the questionnaire. It was decided to organise these details first in order to place the respondent at ease before asking more complex factual questions. Physical format and layout was largely influenced by question sequencing. However, attention to the typeface and font, as recommended by McColl (1993) was made for clarity and ease of completion.

The knowledge based questionnaire was originally developed for the study of ICU nurses' knowledge of suctioning. There were no previously designed questionnaires related to suctioning. When evaluating knowledge outside of the ICU setting, the questionnaire was subsequently modified to take account of the slight differences between endotracheal and tracheal suctioning. The questionnaire was developed using an expert panel and had been validated through the previous studies.

5.3.3 The observation schedule

The structured observation schedule (Appendix 10) was developed in a similar format to the questionnaire, which enabled comparisons to be drawn between knowledge and practice. This was originally developed from details included in the questionnaire, from published and unpublished instruments (Porter et al. 1986; Oliver and Redfern 1991; Roe 1993; Pretzlik 1994) and from pilot work. The schedule was designed with a scoring system to provide ordinal level data. The observation schedule was adapted for the present study to incorporate a section for comments to be added by the researcher, as it was sometimes necessary to question the practitioners about aspects of their practice.

Table 5.3 Contents of the observation schedule

Observation schedule	Elements of practice observed
Prior to suctioning	Patient preparation Auscultation Hyperoxygenation Method of hyperoxygenation Normal saline instillation Hand washing Use of protective eye wear, aprons, gloves
Suctioning	Catheter size Negative suction pressures Suction technique Duration of procedure Number of suction passes
Post-suctioning	Reconnection to oxygen/ventilation Reduce FiO2 to pre-suctioning parameters Assessment of the patient Providing reassurance Hand washing

The role of non-participant observer was adopted for this study, using a structured method, as this approach was felt to be entirely suitable to the RCT research design and positivistic philosophy that underpinned the study. Observation was selected as an additional strategy because, as Swanwick (1994) suggested, different results could emerge from the two methods, with practitioners demonstrating a level of knowledge that is not reflected in actual practice. Morse and Bottorf (1990) argued that the observational technique is one of the least developed and least utilised research strategy but has enormous potential to contribute to health care practice. The rationale for using observation was to observe behaviour in the practitioner's natural settings in order to gain a more accurate reflection of performance.

This study used a structured approach and followed the principles of non-participant observation. It was therefore agreed at the outset that interaction with the participants, patients and others during the periods of observation would be avoided. Additional strategies were employed to make sure that interaction would not be necessary, such as wearing name badges, providing information about the study in advance and asking the participant to introduce the observer to the patient. A decision was taken not to wear uniform, "scrubs" or a white coat in order not to be mistaken for a member of staff and asked for assistance by other patients. The researchers wore plain clothes, as recommended by Fitzpatrick et al. (1996), whilst avoiding bright colours and clothing with large designs to avoid unnecessary distractions.

In line with the principles of non-participant observation, it was agreed that researcher intervention would be necessary in the event of dangerous or consistently poor practice, or if patient safety was compromised. The participants were aware of this and were also informed that if such an event should occur, the observation would become null and void.

Methodological challenges inherent with this approach have been clearly documented. These include issues of potential researcher/observer influence over the participant's behaviour (Hawthorne and halo effects), potential influence of personal and contextual factors over the participant's behaviour, observer error, reliability of observer rating and the potential for observer drift over time (Fitzpatrick et al. 1996; Fletcher et al. 1992). An attempt was made to minimise these biases by remaining as detached and distant as possible during the observations and allowing a period of acclimatisation prior to collecting the data. In order to minimise the risk of error of leniency or severity, thorough observer training and inter-rater reliability testing took place prior to and during data collection. The methodological challenges of observational research and considerations given are presented in Table 5.4

Table 5.4 Methodological challenges of observational research and actions taken

Methodological challenge	Description	Action taken
Hawthorne effect	This is a type of placebo effect in that the subject's behaviour is altered due to their awareness of participating in the study.	The researcher remained detached and distant from the bedside, did not participate and allowed a period of acclimatisation prior to collecting the data.
Halo effect	This is a tendency for the observer to be influenced by one characteristic in their rating of other unrelated characteristics.	The researcher remained detached and distant from the bedside and did not participate. The items on the structured observation schedule were objective.
Personal and contextual factors	Behaviour could be altered if the subjects had a "bad" day or if they were being observed in an unfamiliar environment.	Participants were observed performing more than one suction pass and were always observed in their own practice environment.
Observer error	Elements of practice could be missed or misinterpreted during the period of observation.	Inter-rater reliability testing took place at the beginning and half way through the study. Prior to each observation, the observer checked that key items were clearly visible.
Reliability of observer rating	Problems could occur if the observer does not consistently observe elements of practice and error could occur.	Inter-rater reliability testing took place at the beginning and half way though the study to ensure that this did not occur. Observation schedules were double marked for consistency.
Observer drift over time	This could occur if the observer fails to observe elements of practice or errors occur over time.	Inter-rater reliability testing took place at the beginning and half way though the study, percent agreements and kappa values demonstrated that this did not occur.
Ethical issues	If unsafe or unacceptable practice is observed, researcher intervention might be necessary.	A decision was made to intervene if patient safety should become compromised. The observation would become null and void, but in the event this did not occur.

5.3.4 Composition of expert panel

The questionnaire and observation schedule were discussed with a range of senior critical care practitioners, who made up an expert panel. This included senior nurses from two critical care units, four intensive care and high dependency lecturers, two lecturer practitioners (employed jointly between the Trusts and University), and two specialist respiratory physiotherapists. The instruments were also discussed with the Director of ICU and a Consultant Anaesthetist. Amendments were made according to the comments received prior to pilot testing.

5.3.5 Validity and reliability of the research instruments

Both instruments were piloted on a number of occasions using experienced and inexperienced nurses from the critical care and ward environment. The questionnaire and observation schedule were used in two previous research studies that are reported elsewhere. The instruments were not originally piloted on physiotherapists. However, the content and format of both instruments were discussed and agreed by a specialist physiotherapist connected to the main study site.

In previous work (Day et al. 2001; 2002b), the observation schedule was tested extensively for inter-rater reliability (Cohen 1968). Kappa co-efficients ranged from 0.67 (for one item only) to 1.0 and percent agreement from 80 to 100%, indicating a good level of agreement. For the current study, inter-rater reliability testing also took place at the start and at the mid point phase of data collection and reliability was tested using a second observer (Appendix 14). For each category of the observation schedule, an agreement matrix was formulated. This two-dimensional matrix enabled percent agreements and kappa values to be calculated. Robson (1993) suggested that it is unusual to have complete agreement (100%) in observational research. However, there is a consensus amongst behavioural scientists that an agreement of greater than 70% is necessary, 80% is adequate and 90% is good (Hartmann 1977; House et al. 1981).

At the start of data collection, percent agreements ranged from 89 to 100%. At the mid point stage, percent agreements ranged from 82 to 100%. These calculations demonstrated an acceptable level of agreement. Similar conclusions were drawn from calculations using the kappa formula (Cohen 1968). Kappa measurements range from 0.0 (no agreement) to 1.0 (complete agreement). At the start of data collection, kappa co-efficients ranged from 0.7 (for one item only) to 1.0. At the mid point stage, kappa co-efficients ranged from 0.6 (for one item only) to 1.0. A total of 24 items were tested using the kappa formula. However, for a number of these items kappa remained at 0.0 as, although there had been no disagreement, there had been no opportunity to observe more than one category within the agreement matrix. Nevertheless, 100% agreement was still achieved.

There is a general consensus among researchers that a kappa value of 0.4 to 0.6 is fair, 0.6 to 0.75 is good and above 0.75 is excellent (Fliess 1981; Robson 1993). An acceptable level of inter-rater reliability was therefore demonstrated.

5.4 Research settings

The study took place over two large inner London NHS Trusts. Both were London teaching hospitals, although one was a tertiary referral centre that received patients from other centres for specialist procedures, such as weaning from mechanical ventilation and cardiothoracic services.

5.4.1 Clinical setting

On one of the sites, the observations took place in a clinical setting. Participants were observed suctioning actual patients in a real life context. In most acute Trusts, it is common practice to restrict the number of wards caring for patients with tracheostomies, in order to promote high standards of care and ensure that clinical skills are retained. In the clinical setting, practitioners from six wards took part in the study. This included a six-bedded medical HDU, four-bedded surgical HDU, four-bedded cardiothoracic HDU, sixteen-bedded respiratory unit, an Ear Nose and Throat ward and a general medical ward. These wards were selected as they represented the majority of wards within the Trust that cared for patients with tracheostomies.

5.4.2 Simulation setting

On the other site, the observations took place using simulation. The simulation took place in a clinical setting, at an empty bed space on the participant's own ward, and was based on an actual patient scenario (Appendix 15). The decision to use simulation was based on the literature (Roberts et al. 1992; Cioffi 2001) as a number of authors have suggested that this is a suitable way for assessing and evaluating performance (Sloan et al. 1995; Alinier et al. 2004). However, during the design of this study, this became particularly pertinent to one of the research centres, as a substantial portion of Ear, Nose and Throat (ENT) surgery had moved to a nearby Trust. Although patients with percutaneous tracheostomies were still occasionally transferred from ICU to the high dependency settings, these changes in service provision meant that the practitioner's were exposed to caring for patients with tracheostomies on a less frequent basis. This was an unexpected change in service delivery that occurred with little prior notice. Nevertheless, in spite of this, the need for safe tracheostomy management and the need for practitioners to perform this technique correctly and according to research evidence remained a high priority for the Trust. For these reasons, the study was felt to be important and evaluating practice through simulation believed to be a suitable way of implementing change.

A number of other educational programmes, including Intermediate and Advanced Life Support and courses including the Acute Life Threatening Events Recognition and Treatment (ALERT™) course and Care of the Acutely Ill Surgical Patient (CCrISP™) are delivered and assessed using this format for doctors and other healthcare professionals (Smith et al 2002; Smith and Poplett 2004; White and Garrioch 2002).

In the simulation setting, practitioners from three wards took part in the study. This included a four-bedded medical HDU, a four-bedded surgical HDU, and an 18 bedded Ear Nose and Throat ward. Like the clinical setting, these wards were selected as they also represented the majority of wards that cared for patients with tracheostomies.

5.5 Sample

The sample consisted of registered nurses and chartered physiotherapists. Both groups were selected as they regularly suction patients within their clinical roles. The sample size selected was initially 96, consisting of 24 practitioners from each professional group on each of the two study sites. This was based on the number of practitioners available to participate in the study within the given time frame.

In order for the sample to be representative of the total population, nurses from all grades were selected from the off duty rota. The sample was subsequently stratified into "junior" and "senior" nurses on each of the study sites in an attempt to achieve a balanced sample. "Junior" nurses were identified as D and E grade nurses (or band 5 of the *Agenda for Change* grading structure) and "senior" nurses were F and G grade nurses (band 6). The nurses were subsequently randomly assigned to their respective groups.

Physiotherapists were also selected from the off duty rota and were stratified according to "junior" and "senior" physiotherapist. "Junior" physiotherapists were identified as basic grade physiotherapist and "senior" physiotherapists were senior I and senior II grades. Consultant physiotherapists and clinical specialists were excluded from the study, as they are responsible for the provision of education relating to trachesotomy management.

Within the design, it was acknowledged that the context in which patients are suctioned would differ between the two professional groups. For nurses, patients would be suctioned when clinically indicated but for physiotherapists suctioning would normally be associated with treatment and chest physiotherapy. Nevertheless, despite these differences, suctioning should still be performed according to current best evidence (Day 2000).

5.6 Randomisation

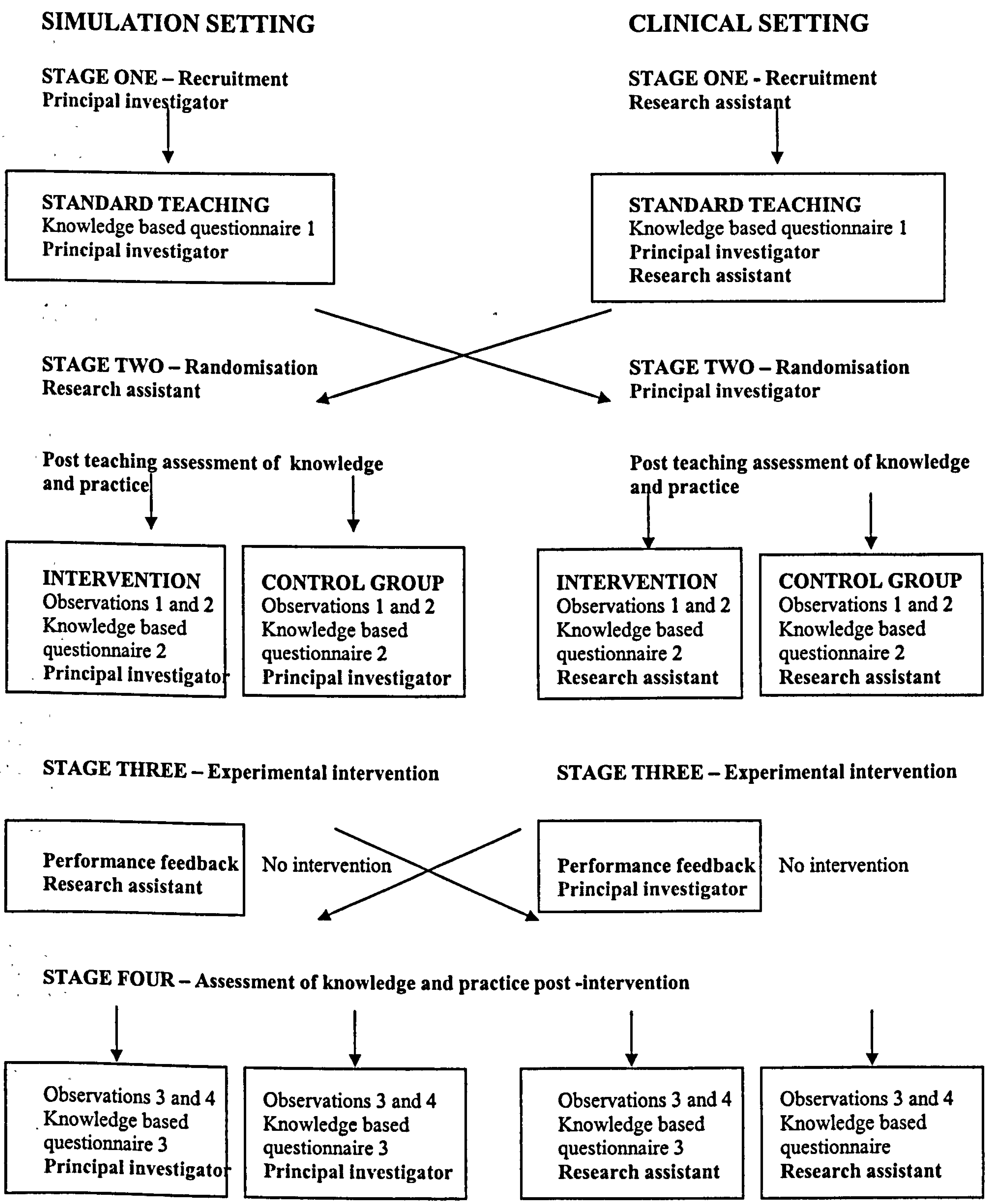
Participants were randomly assigned to groups, in order to minimise selection bias. A blocked stratified (by profession and seniority) random allocation sequence was generated by someone not involved in recruitment or data collection (one of the academic supervisors) using a table of random numbers generated by Excel. Allocations were placed in sequentially numbered opaque sealed envelopes which were not opened until after consent was obtained, as recommended. The size of the random blocks was varied and concealed from the researchers. This process was designed to ensure that those recruiting to the study remained blind to allocation prior to the point of recruitment. Lack of blinding at this point is a major source of bias (Jadad 1998).

5.6.1 Project personnel

Two people were involved with the project; the principal investigator and a research assistant. The role of key personnel was fundamental to the research design, in order to achieve the necessary blinding in relation to recruitment and randomisation. Both held honorary contracts with the two Trusts. A research assistant was employed for a one-year period to assist with data collection in the clinical setting and to deliver the experimental intervention in the simulation setting. The research assistant's main role was to collect data and provide performance feedback, although this also included delivering some of the standard teaching sessions. The research assistant's job description was drawn up and the post was advertised in both nursing and physiotherapy journals. The post was filled by a critical care nurse with a background in research.

The research assistant delivered some of the standard teaching sessions in the clinical setting. The majority of sessions were undertaken by the principal investigator. This was primarily for consistency, although due to practicalities and the number of sessions, this was not always possible. The research assistant also administered and delivered the performance feedback to those in the intervention group in the simulation setting. Figure 5.2 shows the principal investigator and research assistant roles in relation to the study design.

Figure 5.2 Flow diagram to illustrate design and the role of project personnel



5.6.2 Research assistant training

Following an initial orientation to the Trust, the research assistant observed a number of the conventional teaching sessions. The importance of following an identical format was emphasised, and this involved a few trial runs with the research assistant practicing the teaching session and the principal investigator observing. The practical demonstrations were also rehearsed to ensure a consistent approach. However, it was acknowledged that whilst the sessions were standardised, with both educators providing the same verbal, visual and written material, and indeed placing the same emphasis on certain issues, there were some things that could not be identical, such as the questions participants asked.

The research assistant also received training for undertaking the observations. This initially took the form of a colleague suctioning a mannequin in the clinical skills laboratory, with the principal investigator demonstrating how to use the observation schedule. A number of observations were rehearsed this way, with the principal investigator observing and giving feedback to the research assistant. Several observations were also rehearsed in the clinical setting involving patients and colleagues that were not part of this research study.

To ensure consistency in delivering the performance feedback, it was important to ensure that both principal investigator and research assistant took the same approach. This was also rehearsed with the principal investigator acting as a practitioner and the research assistant delivering the feedback and *vice versa*.

5.7 Power

The power of a study is normally set at a minimum of 0.8, or 80%, which means that there is an 80% chance of detecting a difference. Increasing power reduces the likelihood of not detecting a true effect (i.e accepting the null hypothesis when it is false). This is a Type II error (Lipsey 1990; Ingram 1998). As Endacott and Botti (2005) identified, in situations of low power, where there is an inadequate sample size, effects may go undetected.

The effect size refers to the minimum size of difference to be detected. This is determined by the clinical importance of the difference and can be derived from a similar study or through pilot work. Earlier work (Day et al. 2001) suggested that a large effect size (d) of 1.2 or 1.3 could be expected, representing a difference in mean practice scores of 3 or more points between groups. An initial power analysis calculation based on previous data (Day et al. 2001) showed that a sample size of 10-12 per group could be powerful enough to detect this difference (alpha 0.05, beta 0.8, sd 2.5 calculated using G-Power statistical software for power analysis). Whilst this study is similar in design to earlier work, there are nevertheless certain differences. Although it evaluated the effectiveness of education, in this study the independent variable manipulated was the performance feedback and the effect of *additional* input after education is likely to be smaller than the effect of education compared to none. Also because the setting and context differed from earlier work it is uncertain whether the variance seen in those populations which are used to estimate power would be the same and certainly there was potential fro greater variation which would reduce power. Further, the potential clinical significance of smaller differences in *practice* is high. Therefore a decision was made to increase numbers to reflect the maximum number of subjects that would be available to participate in the study within a given time frame. This was estimated at approximately fifty per group. On this basis, using the existing data and the same parameters, the study was estimated to be sufficiently powerful to detect an effect (d) of 0.57 which equates to a difference in mean score of less than 1.5 points

5.8 Educational interventions

The educational interventions consisted of the following:

Intervention group: Standard intervention: conventional teaching programme, discussion of research recommendations and practical demonstration. This was followed by individual performance feedback (experimental intervention).

Control group: Standard intervention: conventional teaching programme, discussion of research recommendations and practical demonstration (control intervention).

The specific details of the standardised teaching programme and the salient features of the individualised performance feedback framework were discussed in Chapter four.

5.9 Data collection process

Once access permission had been granted and ethical approval obtained, meetings were arranged with key stakeholders to discuss the data collection process on each site. Provisional dates for the standard teaching sessions were agreed and arrangements made to speak to potential subjects and discuss the nature of the study. This occurred prior to any formal invitation to take part in the research. For physiotherapists, this involved being present at a team meeting and, for nurses, discussions at ward level. Initially only four of the six wards were approached. However, as not all were able or willing to participate, invitations were subsequently extended to the remaining wards. A box for returning consent forms was placed in each ward or department.

Following the standard teaching sessions (week 0), arrangements were made to undertake the first two observations. This was scheduled to take place within six weeks of teaching (week 1 – 6). The second questionnaire was also completed at that stage. Each participant was observed performing two tracheal suction passes, as statistical regression can occur if subjects are observed on only one occasion, leading to a shift in mean scores (Campbell and Stanley 1966). Carrying out two observations at each stage of data collection also increased the validity of the scores. The participants were given a code and informed that the purpose of the code was for further observations to be carried out and the questionnaire completed. The participants were asked to suction in the usual way and at an appropriate time for the patient.

The participant information sheet gave general information about the topic under investigation, but in an attempt to minimise the "Hawthorne" effect and gain an accurate reflection of practice, this did not include specific details. It was emphasised that the researcher would be unable to participate in the suctioning procedure or answer any questions. It was also reiterated that information gained would be treated with the strictest of confidence and that subject anonymity would be preserved. Prior to each observation, the observer checked that key items such as the suction pressure gauge and tubing were clearly visible. During the observation, however, the observer remained distant from the bedside.

The intervention group were given performance feedback seven to ten weeks after teaching, which provided a four-week window for giving feedback. This period was felt to be important for practical reasons, such as annual leave and night duty, as a shorter time frame could have resulted in attrition. The visit was arranged for when each participant was on duty. There was no requirement for them to be suctioning at that time. In the simulation setting, the research assistant gave feedback, as the principal investigator undertook the observations and was blind to the randomisation process. In the clinical setting, the principal investigator provided feedback The final set of observations took place between weeks 11 and 16. These were also carried out before the completion of the last knowledge based questionnaire and under identical conditions to previously. A total of 380 observations were undertaken.

5.10 Measurements

With the exception of categorical variables, most of the data were ordinal level. In order to create a non parametric version, the responses were ranked (Conover 1980). The questionnaire and observation schedule were both sub-divided into events prior to, during and post-suctioning and scores were allocated to each section. For the majority of items, one mark was awarded for each correct response and no mark awarded for an inappropriate response. This gave a maximum score of twenty points; eight points for prior to suctioning, seven points during suctioning and five points post-sectioning. A scoring legend was formulated and identical scores were allocated for the relevant items from the questionnaire and observation schedule, which enabled direct comparisons to be made between knowledge and observed practice. However, a few of the knowledge-based questions were unable to be observed in practice. For example, it is not possible to differentiate whether a suction catheter reaches the patient's carina or the end of the tracheostomy tube by observation alone. Such questions were not allocated scores as no comparisons could be made between knowledge and practice.

Mean observation scores were calculated from the two observations carried out per subject, and section sub-scores were subsequently aggregated to provide an overall score for knowledge and practice. This process was repeated at each stage of data collection. Scoring systems can either be positive or negative. Using a negative scoring system, one mark would be allocated for a correct response and one mark subtracted for an incorrect response. Historically, some of the medical literature has taken this approach. However, this system was not adopted for this study, as the underlying philosophy was to encourage the participants and promote improvement. The possible range of scores, with a positive scale, was 0 to 20. Had a negative scale been adopted, the range would have been -20 to +20. Some participants would have ended up with negative scores, which could have had a serious impact on confidence, or even motivation to continue with the study. Furthermore, most of the data analysis was undertaken on the ranked scores. The results, therefore, would have been the same regardless of the scale. The timing of measurements are illustrated in Table 5.6

Table 5.5 Timing of measurements

Research method	Time frame	Measurement
Knowledge based questionnaire 1	Prior to teaching (week 0)	Knowledge score
Observations 1 & 2	Post teaching (Week 1 – 6)	Practice score
Knowledge based questionnaire 2	Post teaching (Week 1 – 6)	Knowledge score
Observations 3 & 4	Post intervention (Week 11 – 16)	Practice score
Knowledge based questionnaire 3	Post intervention (Week 11 – 16)	Knowledge score

5.10.1 Correlation of scores between markers

The baseline knowledge questionnaires and observation schedules were double marked for consistency, and to establish whether there was the potential for any discrepancy. Subsequent questionnaires were single marked.

5.11 Data analysis

Observational and questionnaire data were analysed using quantitative methods. This included both descriptive and inferential statistics. The data were coded and entered onto a computer system running SPSS for Windows (Version 13.0) and a coding legend produced.

5.11.1 Descriptive statistics

Frequency ratings and percentages were calculated for nominal level data. This included demographic data and the individual items within each suctioning category. Means, medians and ranges were calculated for ordinal level data.

5.11.2 Inferential statistics

Much of the data were analysed by non-parametric statistical tests. Item differences for nominal level variables were analysed by *Chi* square tests. For ordinal level data, knowledge scores changes before and after teaching, and before and after performance feedback were analysed by Wilcoxon Signed Rank test. Practice scores changes before and after performance feedback were also analysed by Wilcoxon Signed Rank test. Mann Whitney U tests were used to analyse score differences between the performance feedback and control groups for knowledge before and after teaching, and following performance feedback. Similarly, for practice, score differences between groups post teaching and performance feedback were also analysed by Mann Whitney U test.

Differences in proportions before and after teaching, and before and after performance feedback were analysed by McNemar tests. The correspondence between knowledge and practice was analysed by Kendall's tau correlation co-efficient. When the two data sets were subsequently merged, knowledge and practice was analysed using ANOVA on ranked scores to produce a non parametric equivalent test (Conover 1980). For each test, a significance level of $p < 0.05$ was accepted as statistically significant. All tests were two-tailed. A summary of data analysis is presented in Table 5.7

Table 5.6 Data analysis summary

Research question(s)	Statistical test	Rationale
1. Baseline data and changes after teaching		
Knowledge		
Individual item differences before teaching	*Chi* square	To test for differences between groups for nominal level variables
Knowledge score differences between groups before teaching	Mann Whitney U	To test for score differences between groups before teaching
Individual item differences post teaching	*Chi* square	To test for differences between groups for nominal level variables post teaching
Knowledge score changes before and after teaching (Hypothesis 1)	Wilcoxon Signed Rank	To test for improvements in scores by group, before and after teaching
Knowledge post teaching (Hypothesis 1)	Mann Whitney U	To test for knowledge score differences between groups post teaching
Individual item changes before and after teaching	McNemar	To compare difference in proportions between paired groups before and after teaching
Practice		
Practice post teaching (Hypothesis 1)	Mann Whitney U	To test for practice score differences between groups post teaching
Individual item differences post teaching	*Chi* square	To test for differences between groups for nominal level variables post teaching
Correspondence between knowledge and practice		
Correlation between knowledge and practice	Kendall's tau	A correlation co-efficient for ordinal level data to compare the magnitude of the relationship at baseline level
Individual item differences between knowledge and practice	McNemar	To compare the difference in proportions between knowledge and practice for paired groups
2. Effectiveness of experimental intervention		
Knowledge		
Individual item changes before and after the intervention	McNemar	To compare the difference in proportions between paired groups pre and post intervention
Knowledge before and after feedback by group (Hypothesis 2)	Wilcoxon Signed Rank	To test for improvements in knowledge scores by group, before and after feedback
Knowledge score differences between groups (Hypothesis 2)	Mann Whitney U	Mann Whitney U test used as there was no significant difference between group and profession by ANOVA
Practice		
Practice post intervention (Hypothesis 2)	Wilcoxon Signed Rank	To test for improvements in practice scores by group, before and after feedback
Practice score differences between groups	Mann Whitney U	Mann Whitney U test used as there was no significant difference between group and profession by ANOVA
Item changes prior to and post intervention	McNemar	To compare difference in proportions between paired groups pre and post intervention
Correspondence between knowledge and practice		
Correlation between knowledge and practice (Hypothesis 3)	Kendall's tau	A correlation co-efficient for ordinal level data to compare the magnitude of the relationship post intervention
Item differences between knowledge and practice	McNemar	To compare difference in proportions
Merged data set		
1. Effectiveness of experimental intervention		
Comparison of knowledge across settings and professions by group (Hypothesis 4)	Three-way ANOVA (ranked)	To compare differences between groups across settings and professions
Comparison of practice across settings and professions by group (Hypothesis 4)	Three-way ANOVA (ranked)	To compare differences between groups across settings and professions
Correspondance between knowledge and practice (Hypothesis 3)	Kendall's tau	To compare relationship between knowledge and practice on merged data

5.12 Research governance, access permission and ethical approval

The research governance framework set out by the Department of Health (DoH 2002) identifies the minimum standards for the governance of research in health and social care. The framework aims to promote high quality research and ensure that standards and protocols for conducting research are understood and met. Ethical issues, science, information, project management, health and safety and economic factors are key components of the research governance framework.

Permission for access was obtained through the Director of Nursing on both study sites. Permission was also obtained from the Head of Therapies on each site. The research assistant and principal investigator held honorary research contracts with both Trusts for the duration of the data collection period.

Ethical approval (Appendix 3) was obtained from the Local Research Ethical Committee (LREC) of the main research site. Approval to extend the study to an additional site was subsequently obtained through Chair's action and approval indicated that there was no objection to the study being conducted at the second site (Appendix 3). Research and development (R and D) approval was also obtained from both study sites (Appendix 4).

The nature of the project was explained both verbally and in writing by the researcher. Each subject was given a participant information sheet (Appendix 5) informing him or her about the study and their option to withdraw at any time. Written consent was also obtained and all signatures witnessed by someone not involved in the study (Appendix 6). Unlike the ICU setting where patients were often sedated, in this study the patients being suctioned were usually awake. Patients were therefore given a patient information sheet (Appendix 7) about the study and verbal consent was obtained. Although the presence of a tracheostomy sometimes prevented patients from actually verbalising their consent, all were able to either mouth their response or nod their head to demonstrate this.

In relation to the observations, the participants were observed suctioning in the usual way and at an appropriate time for the patient. Each participant was informed that researcher intervention would be necessary in the event of dangerous or consistently poor practice, or if patient safety was compromised. For example, if the period between suctioning the patient and recommencing ventilation or attaching oxygen was delayed, or the patient's oxygen saturation levels started to fall more than a few percent, researcher intervention would have been necessary. Participants were also informed that if such an event should occur, the observation would become null and void.

The participants were assured that confidentiality would be maintained at all times throughout the study, that data would be secured in a locked cupboard and destroyed on its completion. Although the participants were not identified by name in any of the documentation, they were allocated a code in order for subsequent observations to be carried out.

5.13 Chapter summary

The study aimed to evaluate the effectiveness of individual performance feedback as a framework for improving knowledge and practice of tracheal suctioning. The study consisted of four main stages; a standardised, conventional teaching session that was delivered to both an intervention and control group; direct observation followed by the completion of a knowledge-based questionnaire; individualised performance feedback (experimental intervention) and, finally, a second set of observations and questionnaire. Data were collected from two different settings; a clinical setting involving patients and a simulation setting based around patient scenarios. Previous research had identified a discrepancy in knowledge and skills with practitioners practicing against research recommendations. It was hypothesised that incorporating performance feedback within the design of this study would encourage the retention of knowledge and skills, and promote evidence based practice.

CHAPTER SIX: RESULTS FROM THE SIMULATION SETTING

6.1 Introduction

This chapter describes and analyses the findings from the simulation setting. This aspect of the study was conducted at a large inner London teaching hospital and involved nurses and physiotherapists from two HDU's and one ENT ward. Participants were observed in their own practice areas, at an empty bed space, but the observations took place using simulation. The findings are presented in the following sequence:

6.2 Characteristics of the sample and demographic data

6.3 Baseline data and changes after standard intervention (Hypothesis 1)

- 6.3.1 Knowledge prior to teaching
- 6.3.2 Knowledge post teaching (Hypothesis 1)
- 6.3.3 Correspondence between knowledge and practice
- 6.3.4 Summary of baseline findings

6.4 Effectiveness of experimental intervention (Hypothesis 2)

- 6.4.1 Knowledge post intervention
- 6.4.2 Practice post intervention
- 6.4.3 Correspondence between knowledge and practice post intervention (Hypothesis 3)

6.5 Chapter summary

6.2 Characteristics of the sample and demographic data

Thirty nine subjects participated in the study; 26 nurses and 13 physiotherapists. The majority were female (n = 33, 84%), and aged over 30 (n = 22, 56%). Half (n = 20, 51%) had less than 5 years post registration experience. More than two thirds of the sample (n = 27, 69%) had previous critical care experience (see Table 6.1).

Table 6.1 Demographic data

Gender n (%)		Profession n (%)		Age range n (%)		Postregistration experience (years) n (%)		Previous critical care experience n (%)	
Female Male	33 (85) 6 (15)	Nurse Physio	26 (67) 13 (33)	< 30 30-39 >39 Mean	16 (41) 9 (23) 14 (36) 13 (33)	<2 2-5 >5 Mean	12 (31) 8 (20) 19 (49) 13 (33)	Yes No	27 (69) 12 (31)

There were no significant differences between the performance feedback or control groups for any of the demographic characteristics ($p > 0.05$).

6.3 Baseline data

6.3.1 Knowledge prior to teaching

An overall 'knowledge' score was computed by giving a score of one for each of the twenty aspects of suctioning mentioned. This gave a maximum possible score of 20, and minimum of zero. At the initial baseline assessment, none of the participants demonstrated complete accuracy in their knowledge base. The maximum score achieved was seventeen, with a median of ten. Table 6.2 shows the mean and median scores by group.

Table 6.2 Mean, median and range of scores for knowledge prior to teaching.

Group	Mean (Standard deviation)		Median (Range)	
Feedback	9.83	2.176	10	5-13
Control	10.67	2.852	11	6-17
Overall	10.28	2.564	10	5-17

The majority of participants (n = 32, 82%) knew how to adequately prepare the patient prior to suctioning. Similarly, most (n = 32, 82%) were aware that hyperoxygenation prior to suctioning is recommended. Very few participants (n = 7, 18%) stated that the recommended volume of saline to instil prior to suctioning was 0 ml. However, some (n = 9, 23%) indicated that they were aware of the research recommendations and would not routinely use saline. Only one third mentioned hand washing (n = 13, 33%), or the need to use protective eye wear (n = 13, 33%) and half mentioned aprons (n = 20, 51%). However, the majority (n = 36, 92%) stated that gloves would be worn.

Most (n = 24, 77%) were aware of the correct size of suction catheter to use, although few (n = 9, 23%) were able to provide a rationale or recommended formula for calculating this. Few (n = 8, 20%) were able to report the recommended suctioning pressures (less than 20 kpa) and some (n = 6, 15%) believed that suction pressures of 20 kpa or more are recommended. Fifty one percent (n = 20) correctly reported the recommended duration for suctioning.

All except one (n = 39, 97%) participant reported that they would perform chest auscultation following suctioning. The majority (n = 28, 72%) were aware of the need to reconnect the oxygen supply or any other form of respiratory support therapy within 10 seconds of suctioning. However, less than two thirds (n = 23, 59%) reported that they would reduce the fraction of inspired oxygen to the patient's previous setting. Only three participants (8%) reported that they would wash their hands after suctioning and less than one third (n = 12, 31%) would reassure the patient. There were no significant differences between the groups at baseline level (U = 154.000, p = 0.335). There were no statistically significant association between group and knowledge for any aspect of suctioning ($p > 0.05$).

6.3.2 Knowledge post teaching (hypothesis one)

The first hypothesis predicted that participants would demonstrate an increased level of knowledge after initial teaching. Post teaching knowledge scores were compared with those prior to teaching. Overall knowledge scores post teaching were significantly better than knowledge scores prior to teaching (Z = -5.294, p = 0.001). In

The majority of participants (n = 32, 82%) knew how to adequately prepare the patient prior to suctioning. Similarly, most (n = 32, 82%) were aware that hyperoxygenation prior to suctioning is recommended. Very few participants (n = 7, 18%) stated that the recommended volume of saline to instil prior to suctioning was 0 ml. However, some (n = 9, 23%) indicated that they were aware of the research recommendations and would not routinely use saline. Only one third mentioned hand washing (n = 13, 33%), or the need to use protective eye wear (n = 13, 33%) and half mentioned aprons (n = 20, 51%). However, the majority (n = 36, 92%) stated that gloves would be worn.

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6.3.2 Knowledge post teaching (hypothesis one)

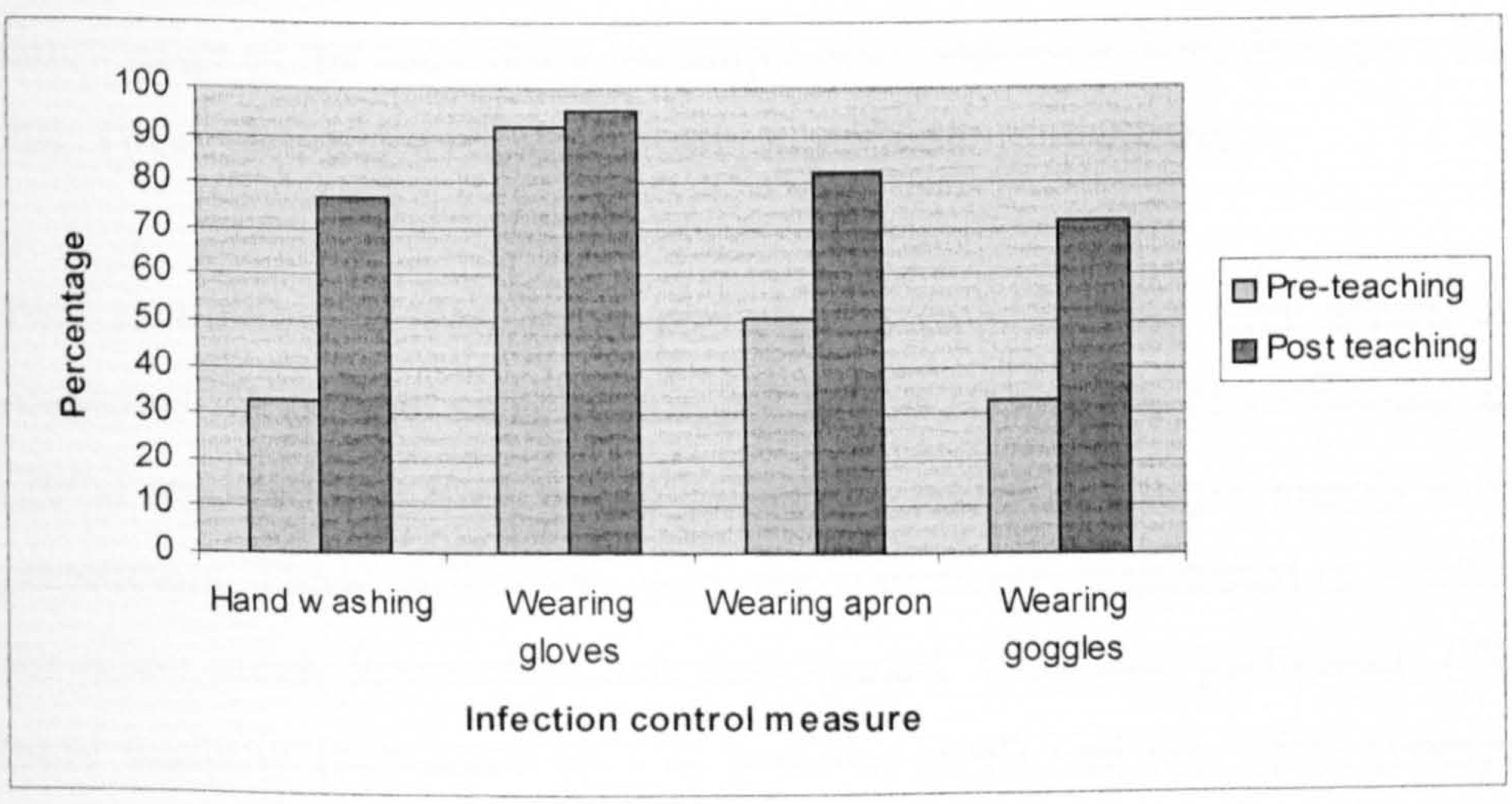
The first hypothesis predicted that participants would demonstrate an increased level of knowledge after initial teaching. Post teaching knowledge scores were compared with those prior to teaching. Overall knowledge scores post teaching were significantly better than knowledge scores prior to teaching ($Z = -5.294$, $p = 0.001$). In the performance feedback group, median scores increased from 10 to 14.5, and from 11 to 15 in the control group, as shown in Table 6.3.

Table 6.3 Score changes post teaching.

Group	Mean	Std	Median	Range	Mean/Median Change	
Feedback	14.39	2.913	14.50	9-19	4.56	4.50
Control	14.00	2.852	15.00	4-17	3.33	3.00
Overall	14.18	2.846	15.00	4-19	3.99	5.00

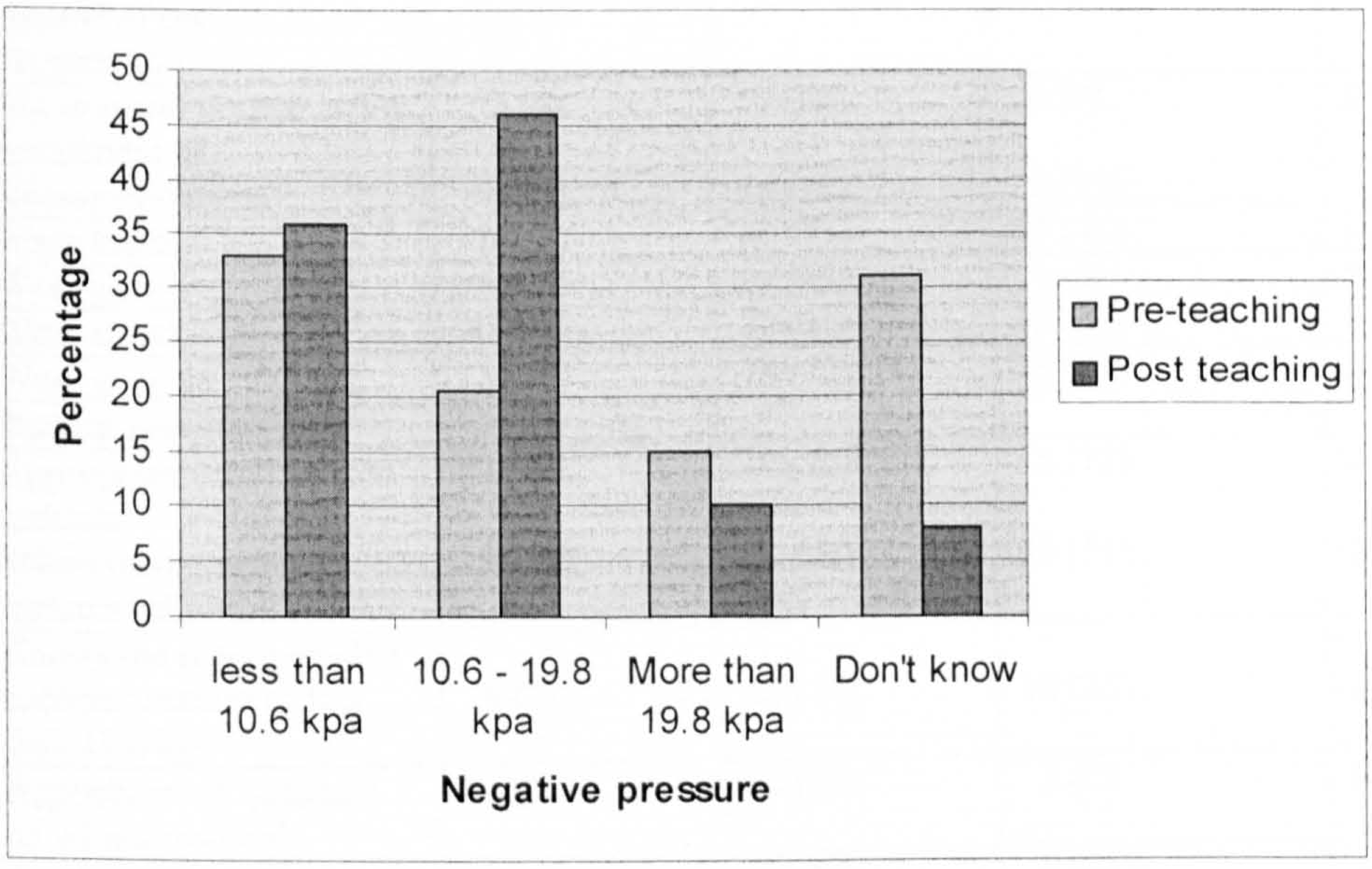
After teaching there was an increase in knowledge for all aspects of infection control. There were statistically significant changes in relation to hand washing as seventeen more participants (n = 30, 77%, $p < 0.001$) reported that hands should be washed and fifteen more reported that eye protection should be worn (n = 28, 72%, $p = 0.001$). Similarly, twelve more participants (n = 32, 82%) reported that aprons should be worn ($p = 0.040$).

Figure 6.1 Knowledge relating to infection control recommendations before and after teaching



In relation to normal saline instillation, there were few changes, with only three further participants (n = 10, 8%) reporting that saline should not be used (Table 6.5). The proportion that were aware of the recommended size of suction catheter increased from 62% (n = 24) to 77% (n = 30), with many more (n = 21, 54%) aware of the appropriate formula. There were statistically significant changes in relation to knowledge of recommended suction pressures, as this improved from 21% (n = 8) to 46% (n = 18, p = 0.021), although some (n = 7, 18%) were still either unsure or reporting excessively high pressures (Figure 6.2).

Figure 6.2 Knowledge of suctioning pressures before and after teaching



Knowledge of the suctioning technique also improved from 56% (n = 22) to 77% (n = 30). These changes were statistically significant (p = 0.039).

Post suctioning, several more participants (n = 3, 7%) were aware of the need to reconnect the patient's oxygen supply within 10 seconds of suctioning and eight more (20%) reported that they would reduce the patient's oxygen supply to pre suctioning parameters. These differences were not statistically significant (p = 0.508). However, for some areas, knowledge had deteriorated. Only one participant (2%) mentioned hand washing (compared to 3 at baseline level) and six, 15%, (compared to 12 at baseline level) reassured the patient post suctioning.

Table 6.4 Accuracy of knowledge before and after teaching .

Aspect of suctioning	Knowledge prior to teaching *n* (%)	Knowledge post teaching *n* (%)	Change *n* (%)	McNemar p =
Prior to suctioning				
Patient preparation	32 (82)	34 (87)*	2 (5)	p = 0.754
Pre-oxygenation	32 (82)	32 (82)	0 (0)	p = 1.00
If pre-oxygenated, method of pre-oxygenation	32 (100)	32 (100)	0 (0)	p = 1.00
Not to instill normal saline	7 (18)	10 (26)	3 (9)	p = 0.375
Awareness of recommendations	9 (23)	18 (18)	9 (23)	
Wash hands	13 (33)	30 (77)	17 (44)	**p < 0.001 ****
Wear gloves	36 (92)	37 (95)	1 (3)	p = 1.00
Wear apron	20 (51)	32 (82)	12 (31)	**P = 0.004 ****
Wear goggles	13 (33)	28 (72)	15 (39)	**p = 0.001 ****
During suctioning				
Appropriate sized suction catheter	24 (62)	30 (77)	6 (15)	p = 0.344
Stated recommended formula/rationale	9 (23)	21 (54)	12 (31)	p = 0.375
Knows the recommended suction pressure of less than 19.8 kpa	8 (21)	18 (46)	10 (25)	**p = 0.021 ***
Application of pressure on withdrawal only	33 (85)	36 (92)	3 (7)	p = 0.375
To use continuous technique	22 (56)	30 (77)	8 (21)	**p = 0.039 ***
To withdraw with no lateral movement	30 (77)	35 (90)	5 (13)	p = 0.063
Duration of 10-14 seconds	20 (51)	22 (56)	2 (5)	p = 0.791
To use 3 or fewer suction passes	34 (87)	37 (95)	3 (8)	p = 0.250
Post suctioning				
Reconnect to oxygen supply within 10 seconds	28 (72)	31 (80)	3 (8)	p = 0.508
Auscultate chest	38 (97)	36 (92)	-2 (-5)	p = 0.500
Wash hands	3 (8)	1 (3)	- 2 (-5)	p = 0.500
Reassure patient	12 (31)	6 (15)	-6 (-16)	p = 0.109
Return oxygen flow to previous setting	23 (59)	31 (79)	8 (20)	**P = 0.039 ***

* Indicates significance at the 5% level
** Indicates significance at the 1% level

There were no significant differences between the performance feedback and control groups after initial teaching (U = 184.500, p = 0.900). There were no significant differences between groups' knowledge of individual aspects of the suctioning procedure with the exception of patient preparation. Participants in the performance feedback group were more likely to report that they would prepare the patient prior to the procedure (χ^2 = 4.916, df = 1, p = 0.050). However, in view of the number of comparisons and lack of overall difference a single significant result is unsurprising. Therefore it appears that the groups were equivalent prior to the commencement of the experimental intervention.

6.3.3. Correspondence between knowledge and practice post teaching

A practice score out of twenty was computed, with a maximum score of twenty and minimum score of zero. Scores ranged from 7.5 to 19. Table 6.5 shows the comparison of scores for knowledge and practice by group. There were no significant differences between the performance feedback and control groups for practice after initial teaching (U = 162.000, Std 2.537, p = 0.460). Kendalls tau was 0.387 (p = 0.001) which indicated that there was a moderate correlation between knowledge and practice post teaching.

Table 6.5 Correspondence between knowledge and practice post teaching

Group	Knowledge:				Practice:			
	Mean	Std Dev	Median	Range	Mean	Std Dev	Median	Range
Feedback	14.39	2.913	14.50	9-19	12.02	2.039	11.25	9.5-16.5
Control	14.00	2.952	15.00	4-17	12.57	2.925	12.50	7.5-18.5
Overall	14.18	2.846	15.00	4-19	12.32	2.537	11.50	7.5-18.5

Table 6.6 shows the proportion of participants complying with research recommendations when observed in practice, and how this correlated with knowledge.

Table 6.6 Knowledge of recommendations compared to practice

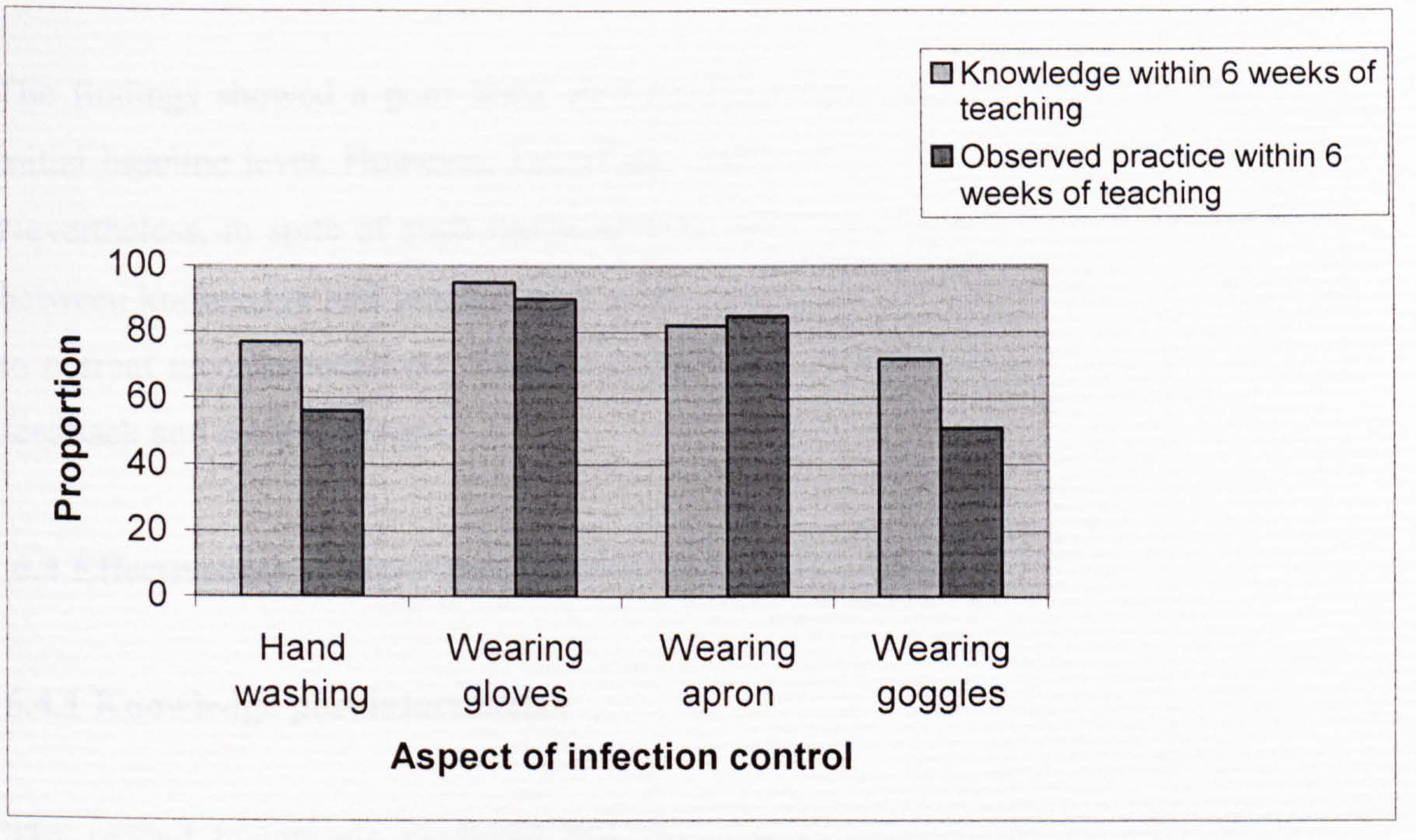
Aspect of suctioning	Knowledge *n* (%)	Practice *n* (%)	% agreement	McNemar p=
Prior to suctioning				
Patient preparation	34 (87)	34 (87)	100	p = 1.0
Pre-oxygenation	32 (82)	17 (44)	53	**p = 0.001 ****
If pre-oxygenated, method of pre-oxygenation	32 (100)	17 (100)	100	p = 1.0
Awareness of recommendation not to instill saline	18 (46)	36 (92)	50	**P < 0.001 ****
Wash hands	30 (77)	22 (56)	73	p = 0.077
Wear gloves	37 (95)	35 (90)	95	p = 0.687
Wear apron	32 (82)	33 (85)	97	p = 1.0
Wear goggles	28 (72)	20 (51)	71	p = 0.077
During suctioning				
Appropriate sized suction catheter	30 (77)	19 (48)	63	**p = 0.007 ****
Suction pressure of 10.6 – 19.8 kpa	18 (46)	11 (28)	61	p = 0.063
Application of pressure on withdrawal only	36 (92)	37 (95)	97	p = 1.0
To use continuous technique	30 (77)	36 (92)	83	**P < 0.001 ****
To withdraw with no lateral movement	35 (90)	31 (70)	89	p = 0.344
Duration of 10-14 seconds	22 (56)	3 (8)	14	p = 0.063
To use 3 or fewer suction passes	36 (95)	39 (100)	10	P = 1.000
Post suctioning				
Reconnect to oxygen supply within 10 seconds	31 (79)	30 (77)	97	p = 0.774
Auscultate chest	36 (92)	16 (41)	44	**P < 0.001 ****
Wash hands	1 (3)	3 (8)	33	p = 0.625
Reassure patient	6 (15)	8 (21)	75	p = 0.687
Return oxygen flow to previous setting	31 (79)	13 (77)*	42	p = 1.0

** Indicates significance at the 1% level

For some elements of suctioning, practice was better than reported in the knowledge-based questionnaire. However, this was not the case for hyperoxygenation. Although the majority (n = 32, 82%) were aware that hyperoxygenation is recommended, less than half (n = 17, 44%) hyperoxygenated in practice, as shown in Table 6.7 This difference was statistically significant (p = 0.001). Although reported knowledge of normal saline instillation recommendations was generally poor (n = 18, 46%), few participants (n = 3, 8%) actually used saline in practice. This difference was also statistically significant (p < 0.001).

Knowledge of infection control measures were generally better reported in the questionnaire than implemented in practice. Although the majority (n = 30, 77%) stated that hands should be washed before suctioning, just over half (n = 22, 56%) washed their hands in practice. Similarly, protective eye wear featured in most of the questionnaire responses (n = 28, 72%) but only half (n = 20, 51%) wore goggles in practice (see figure 6.9). These differences were not statistically significant (p = 0.077).

Figure 6.3 Knowledge and practice of infection control post teaching



Although many (n = 30, 77%) were aware of the appropriate sized suction catheter to use, less than half (n = 19, 48%) used a correct size in practice (p = 0.007). Some other large differences were also noted which did not reach statistical significance. Almost half (n = 18, 46%) were aware of the appropriate suction pressures but only eleven (28%) suctioned within the recommended pressure in practice (p = 0.063). More than half (n = 22, 56%) had knowledge of the recommended time frame for the suction episode, although only three (8%) implemented this in practice (p = 0.063).

Post suctioning, there was a good correspondence for reconnecting the patient's oxygen supply and reducing the FiO2 to the previous setting, but not for other aspects.

Less than half (n = 16, 41%) performed chest auscultation in practice, although almost all (n = 36, 92%) were aware that this is recommended practice. This difference was statistically significant ($p < 0.001$). For hand washing, knowledge and practice remained poor, with only one (3%) indicating this in their questionnaire response and three (8%) washing their hands in practice. Similarly, few participants (n = 8, 21%) reassured the patient after the procedure, which corresponded slightly more favourably than indicated in the questionnaire responses (n = 6, 15%).

6.3.4 Summary of baseline findings

The findings showed a poor level of knowledge for many aspects of suctioning at initial baseline level. However, knowledge scores did improve after initial teaching. Nevertheless, in spite of such improvements, there remained a poor correspondence between knowledge and practice with many participants failing to practice according to current recommendations. These findings were consistent across the performance feedback and control groups.

6.4 Effectiveness of experimental intervention (hypothesis two)

6.4.1 Knowledge post intervention

The second hypothesis predicted that the practitioners who received performance feedback would demonstrate and sustain a higher level of knowledge and practice compared to those who did not receive feedback. In the performance feedback group, mean knowledge scores increased from 14.39 to 15.71. These were significantly better than scores post teaching ($Z = -2.041$, $p = 0.041$). In contrast, the control group showed a small decline from 14.00 to 13.81 (Table 6.7). These were not significantly different to post teaching scores ($Z = -0.696$, $p = 0.486$). Overall, the performance feedback group had significantly higher knowledge than the control group ($U = 104.000$, $p = 0.029$).

Table 6.7 Score changes post intervention.

Group	Mean	Std Dev	Median	Range	Mean/Median Change	
Feedback	15.71	2.229	16	11.00 – 19.00	+1.32	+1.5
Control	13.81	2.882	15	5.00 – 17.00	-0.19	0
Overall	14.66	2.714	15	5.00 – 17.00	+0.48	0

In the performance feedback group, knowledge improved in 14 out of 19 elements of suctioning, remained unchanged in one element and deteriorated in the remaining four elements. The control groups' knowledge improved in 10 elements, remained unchanged for three and deteriorated in the remaining six elements. Most of the changes on individual elements were not statistically significant. However, statistically significant improvements were found for hand washing, with an increased number of practitioners in the performance feedback group (n = 4, 24%) citing this in their questionnaire response ($p < 0.001$).

Table 6.8 Accuracy of knowledge post intervention

Aspect of suctioning	Post teaching *n* (%)	Post intervention *n* (%)	Change	Difference %	MsNemar p=
Prior to suctioning					
Patient preparation					
Feedback	18 (100)	14 (82)	-3 (-18)	-32	p = 0.50
Control	16 (76)	19 (90)	+3 (+14)		p = 0.625
Pre-oxygenation					
Feedback	14 (78)	17 (100)	+3 (+22)	+22	p = 0.125
Control	18 (86)	18 (86)	0 (0)		p = 1.000
Saline recommendations					
Feedback	3 (17)	6 (35)	+3 (+18)		p = 1.000
Control	7 (33)	6 (29)	-1 (-3)	+21	p = 1.000
Wash hands					
Feedback	13 (72)	14 (82)	+1 (+10)	+20	p = 0.625
Control	17 (81)	15 (71)	-2 (-10)		p = 0.500
Wear gloves					
Feedback	18 (100)	13 (76)	-4 (-24)	-24	p = 0.125
Control	19 (90)	19 (90)	0 (0)		p = 1.000
Wear apron					
Feedback	14 (78)	15 (88)	+1 (+10)	+25	p = 0.687
Control	18 (86)	15 (71)	-3 (-15)		p = 0 625
Wear goggles					
Feedback	12 (67)	15 (88)	+3 (+21)	+16	p = 0.453
Control	16 (76)	17 (81)	+1 (+5)		p = 1.000
During suctioning					
Appropriate sized catheter					
Feedback					
Control	14 (78)	14 (82)	0 (+4)	-15	p = 1.000
Stated recommended	16 (76)	20 (95)	+4 (+19)		p = 0.125
formula/rationale					
Feedback	4 (22)	9 (53)	+5 (+31)		p = 0.687
Control	10 (48)	13 (62)	+3 (+14)	+17	p = 0.250
Correct suction pressures					
Feedback	10 (55)	9 (53)	-1 (-2)*	-35	p = 1.000
Control	8 (38)	15 (71)	+7 (+33)		p = 0.065
Pressure on withdrawal only					
Feedback	16 (89)	17 (100)	+1 (+6)	+11	p = 1.000
Control	20 (95)	19 (90)	-1 (-5)*		p = 1.000
To use continuous technique					
Feedback	14 (78)	14 (82)	0 (+4)	-10	p = 1.000
Control	16 (76)	19 (90)	+3 (+14)		p = 0.250
No lateral movement					
Feedback	16 (89)	15 (88)	-1 (-1)*		p = 1.000
Control	19 (90)	20 (95)	+1 (+5)	-6	p = 1.000
Duration of 10-14 seconds					
Feedback	9 (50)	9 (53)	0 (+3)		p = 1.000
Control	13 (61)	13 (61)	0 (0)	+3	p = 1.000
3 or less suction passes					
Feedback	17 (94)	17 (100)	+1 (+6)		p = 1.000
Control	20 (95)	18 (86)	-2 (-9)	+15	p = 1.000
Post suctioning					
Reconnect within 10 seconds					
Feedback	16 (88)	15 (88)	0 (0)	+9	p = 1.000
Control	20 (95)	18 (86)	-2 (-9)*		p = 0.317
Auscultate chest					
Feedback	15 (83)	17 (100)	+2 (+17)	-2	p = 0.50
Control	16 (76)	20 (95)	+4 (+19)		p = 1.000
Wash hands					
Feedback	0 (0)	4 (24)	+4 (+24)	+15	**p < 0.001 ****
Control	1 (5)	3 (14)	+2 (+9)		p = 0.564
Reassure patient					
Feedback	3 (17)	7 (41)	+4 (+24)	+15	p = 0.289
Control	3 (14)	5 (23)	+2 (+9)		p = 0.317
Return oxygen flow to previous setting					
Feedback	6 (33)	13 (76)	+7 (+43)	-24	p = 0.687
Control	2 (19)	18 (86)	+16 (+67)		p = 0.317

** Indicates significance at the 1% level

6.4.2 Practice post intervention

In the performance feedback group, mean practice scores increased from 12.00 to 16.53. These were significantly better than scores post teaching ($Z = -3.392$, $p = 0.001$). In contrast, the control group showed a decline from 12.57 to 10.98. These were significantly worse than scores post teaching ($Z = -2.391$, $p = 0.010$). Overall, the performance feedback group had significantly higher practice scores than the control group ($U = 37.500$, $p < 0.001$).

Table 6.9 Score changes post feedback.

Group	Mean	Std Dev	Median	Range	Mean/Median Change	
Feedback	16.53	3.139	17.00	8.50 – 19.50	+4.53	+5.75
Control	10.98	3.104	11.00	4.00 – 16.50	-1.59	- 0.50
Overall	13.46	4.159	13.50	4.00 – 19.50	+1.14	+2.00

In the performance feedback group, practice improved in 11 out of 19 elements of suctioning and remained unchanged for four elements. In the remaining four components of suctioning, practice had deteriorated. The control group's practice improved in two elements, remained unchanged in four elements and deteriorated in the remaining 13 components of suctioning. Statistically significant improvements were seen in the performance feedback group for preoxygenation, with 10 more participants (59%) preoxygenating in practice ($p = 0.002$). In contrast, the control group showed a 28% deterioration, although the decline was not statistically significant ($p = 0.070$). In the performance feedback group, improvements were seen in relation to duration of the procedure, with more ($n = 6$, 35%) participants suctioning within the correct time frame. These changes were statistically significant ($p = 0.031$). However, there was no change for the control group ($p = 1.000$). Statistically significant improvements were also seen for hand washing in the performance feedback group, with nine more participants (60%, $p = 0.006$) complying with recommended practice. For the control group there was a slight deterioration ($p = 1.000$). In the performance feedback group, there were also statistically significant differences for providing verbal reassurance to the patient, with eight more (47%) participants complying with recommended practice ($p = 0.008$). The control group, in contrast, had deteriorated by 10% ($n = 2$, $p = 0.625$).

Table 6.10 Accuracy of practice post intervention

Aspect of suctioning	Post teaching *n* (%)	Post intervention *n* (%)	Change	Difference %	McNemar p=
Prior to suctioning					
Patient preparation					
Feedback	17 (94)	15 (88)	-2 (-12)*	+2	p = 1.000
Control	17 (81)	14 (67)	-3 (-14)*		p = 0.375
Pre-oxygenation					
Feedback	5 (28)	15 (88)	+10 (+59)	+67	**p = 0.002** **
Control	12 (57)	6 (29)	-6 (-28)*		P = 0.07
Saline recommendations					
Feedback	15 (83)	15 (88)	0 (0)	+14	P = 1.000
Control	21 (100)	18 (86)	-3 (-14)		p = 0.250
Wash hands					
Feedback	10 (56)	12 (71)	+2 (+12)	+12	p = 0.687
Control	12 (57)	12 (57)	0 (0)		p = 1.000
Wear gloves					
Feedback	16 (89)	16 (94)	0 (0)	-5	p = 1.000
Control	19 (90)	20 (95)	+1 (+5)		p = 1.000
Wear apron					
Feedback	16 (89)	17 (100)	+1 (+6)	+16	p = 0.500
Control	17 (81)	15 (71)	-2 (-10)*		p = 0.687
Wear goggles					
Feedback	11 (61)	11 (65)	0 (0)	-14	p = 1.000
Control	9 (43)	12 (57)	+3 (+14)		p = 0.549
During suctioning					
Appropriate sized suction catheter					
Feedback	10 (56)	12 (71)	+2 (+12)	+17	p = 0.687
Control	9 (43)	8 (38)	-1 (-5)*		p = 1.000
Correct suction pressures					
Feedback	5 (28)	10 (59)	+5 (+29)	+34	p = 0.180
Control	6 (29)	5 (24)	-1 (-5)*		p = 1.000
Application of pressure on withdrawal only					
Feedback	18 (100)	16 (94)	-1 (-6)*	-6	p = 1.000
Control	19 (90)	19 (90)	0 (0)		p = 1.000
Continuous technique					
Feedback	16 (89)	15 (88)	-1 (-6)*		p = 1.000
Control	20 (95)	17 (81)	-3 (-14)*	+8	p = 0.375
No lateral movement					
Feedback	13 (72)	14 (83)	+1 (+6)	+16	p= 0.727
Control	18 (86)	16 (76)	-2 (-10)*		p = 0.687
Duration 10-14 seconds					
Feedback	1 (6)	7 (41)	+6 (+35)	+35	**p = 0.031** *
Control	2 (10)	2 (10)	0 (0)		p = 1.000
3 or fewer suction passes					
Feedback	18 (100)	17 (100)	0 (0)	0	p = 1.000
Control	21 (100)	21 (100)	0 (0)		p = 1.000
Post suctioning					
Reconnect in 10 seconds					
Feedback	16 (89)	15 (88)	-1 (-6)*	+13	p = 1.000
Control	14 (67)	10 (48)	-4 (-19)*		p = 0.344
Auscultate chest					
Feedback	8 (44)	12 (71)	+4 (+24)	+29	p = 0.219
Control	8 (38)	7 (33)	-1 (-5)*		p = 1.000
Wash hands					
Feedback	2 (11)	12 (71)	+9 (60)	+55	**p = 0.006** **
Control	1 (5)	0 (0)	-1 (-5)		p = 1.000
Reassure patient					
Feedback	3 (17)	11 (65)	+8 (+47)	+57	**p = 0.008** **
Control	5 (24)	3 (14)	-2 (-10)*		p = 0.625
Return oxygen flow to previous setting					
Feedback	5 (28)	15 (88)	+10 (+59)	+73	**p = 0.002** **
Control	8 (38)	5 (24)	-3 (-14)*		p = 1.000

* Indicates significance at the 5% level
** Indicates significance at the 1% level

6.4.3 Correspondence between knowledge and practice post intervention

Following the experimental intervention, greater improvements were seen in the participant's practice scores when compared to knowledge. Table 6.11 shows the mean and median scores for knowledge and practice by group. In the performance feedback group Kendall's tau was 0.332, which indicated a weaker correlation between knowledge and practice post intervention ($p = 0.078$). This was due to the improvements in practice. In the control group, Kendall's tau was 0.623, which showed a good correlation between knowledge and practice scores ($p < 0.001$).

Table 6.11 Mean and median knowledge and practice scores post intervention

Group	Knowledge post feedback:		Practice post feedback:		Range	
	Mean	Median	Mean	Median	Knowledge	Practice
Feedback	15.71	16	16.53	17.00	11-19	8.5-19.5
Control	13.81	15	10.98	11.00	5-17	4-16.5
Overall	14.66	15	13.46	13.50	5-19	4-19.5

In the performance feedback group, there was a correspondence of greater than 80% for 13 out of 19 elements of suctioning (Table 6.12). The control group had a correspondence of greater than 80% for five elements. The performance feedback group showed a stronger association between knowledge and practice than the control group for patient preparation, hyperoxygenation and infection control.

Statistically significant differences between knowledge and practice were seen in the control group for patient preparation ($p = 0.031$), as most ($n = 19$, 90%) were aware of recommended practice but fewer ($n = 14$, 67%) complied in practice. In relation to hyperoxygenation, many ($n = 18$, 86%) were aware of recommendations but few ($n = 6$, 29%) hyperoxygenated in practice. This difference was statistically significant ($p < 0.001$). For the use of saline, few participants in the performance feedback group ($n = 6$, 35%) had knowledge of recommendations but most ($n = 15$, 88%) avoided using saline in practice. These differences were statistically significant ($p = 0.021$). A very similar picture emerged from the control group, where statistically significant differences were also seen ($p = 0.002$) between knowledge and practice for saline use.

Statistically significant differences were also found in the control group for the appropriate size of suction catheter ($p < 0.001$). There were also differences in relation to duration of the procedure, as many were aware of recommendations (n = 13, 61%) but few complied in practice (n = 5, 29%, p = 0.039).

Differences between knowledge and practice were found for chest auscultation. In the performance feedback group, all participants (n = 17, 100%) were aware of current recommendations but only 12 (71%) performed auscultation in practice. These differences were not statistically significant (p = 0.063). In the control group, almost all (n = 20, 95%) had knowledge of recommended practice but few (n = 7, 33%) performed auscultation in practice. These differences were highly significant (p = 0.000). There were also differences for hand washing in the performance feedback group, with few participants (n = 4, 24%) citing this as an important intervention in their questionnaire responses but more (n = 12, 71%) complied with recommendations in practice. This difference was statistically significant (p = 0.039). For the control group, none of the participants washed their hands in practice and agreement was 0% (p = 0.250).

Table 6.12 Correspondence between knowledge and practice post intervention

Aspect of suctioning	Knowledge *n* (%)	Practice *n* (%)	Percent agreement	McNemar p =
Prior to suctioning				
Patient preparation				
Feedback	14 (82)	15 (88)	93	p = 1.0
Control	19 (90)	14 (67)	73	**p = 0.031 ***
Pre-oxygenation				
Feedback	17 (100)	15 (88)	88	p = 0.50
Control	18 (86)	6 (29)	33	**p = 0.001****
Saline recommendations				
Feedback	6 (35)	15 (88)	40	**p = 0.021 ***
Control	6 (29)	18 (86)	33	**p = 0.002 ****
Wash hands				
Feedback	14 (82)	12 (71)	86	p = 0.625
Control	15 (71)	12 (57)	80	p = 0.453
Wear gloves				
Feedback	13 (76)	16 (94)	81	p = 0.250
Control	19 (90)	20 (95)	95	p = 1.0
Wear apron				
Feedback	15 (88)	17 (100)	88	p = 0.500
Control	15 (71)	15 (71)	100	p = 1.0
Wear goggles				
Feedback	15 (88)	11 (65)	73	p = 0.289
Control	17 (81)	12 (57)	71	p = 0.125
During suctioning				
Appropriate sized suction catheter				
Feedback	14 (82)	12 (71)	86	p = 0.625
Control	20 (95)	8 (38)	40	**p < 0.001 ****
Correct suction pressures				
Feedback	9 (53)	10 (59)	90	p = 1.000
Control	15 (71)	5 (24)	33	p = 0.250
Application of pressure on withdrawal only				
Feedback	17 (100)	16 (94)	94	p = 1.000
Control	19 (90)	19 (90)	100	p = 1.000
Continuous technique				
Feedback	14 (82)	15 (88)	93	p = 1.000
Control	19 (90)	17 (81)	90	p = 0.687
No lateral movement				
Feedback	15 (88)	14 (83)	93	p = 1.000
Control	20 (95)	16 (76)	80	p = 0.125
Duration of 10-14 seconds				
Feedback	9 (53)	7 (41)	78	p = 1.000
Control	13 (61)	5 (29)	33	**p = 0.039 ***
3 or fewer suction passes				
Feedback	17 (100)	17 (100)	100	p = 1.000
Control	18 (86)	21 (100)	86	p = 1.000
Post suctioning				
Reconnect to within 10 seconds				
Feedback	15 (88)	15 (88)	100	p = 1.000
Control	18 (86)	10 (48)	56	p = 0.21
Auscultate chest				
Feedback	17 (100)	12 (71)	71	p = 0.063
Control	20 (95)	7 (33)	35	**p < 0.001 ****
Wash hands				
Feedback	4 (24)	12 (71)	33	**p = 0.039 ***
Control	3 (14)	0 (0)	0	p = 0.250
Reassure patient				
Feedback	7 (41)	11 (65)	64	p = 0.453
Control	5 (23)	3 (14)	60	p = 0.625
Return oxygen flow to previous setting				
Feedback	13 (76)	15 (88)	87	p = 0.250
Control	18 (86)	5 (24)	28	**p < 0.001 ****

* Indicates significance at the 5% level
** Indicates significance at the 1% level

6.5 Chapter summary

This chapter has presented the findings in a simulation setting. Prior to initial teaching, none of the participants demonstrated complete accuracy in their knowledge base for all aspects of tracheal suctioning. Scores ranged from five to 17. There were no significant differences between the performance feedback and control groups ($U = 154.000$, $p = 0.335$). Specific areas of poor knowledge related to the reported use of normal saline instillation, infection control practices, selection of an appropriate catheter size and excessive suction pressures.

Hypothesis one predicted that, following the standard education, the participants would demonstrate a higher level of knowledge. There were slight improvements in the knowledge scores, which ranged from four to 19.00. As anticipated, there were no significant differences between the performance feedback and control groups. However, some participants still reported to use saline and cited excessive suction pressures. For practice, during the baseline observations, none of the participants demonstrated complete accuracy in their suctioning techniques. Observation scores ranged from 7.50 to 18.50, and there were no significant differences between groups ($U = 162.000$, $p = 0.460$). Specific areas of concern related to non-adherence to infection control recommendations and limited use of hyperoxygenation.

Hypothesis two predicted that the subjects who received performance feedback would sustain a higher level of knowledge and practice compared to those who had no feedback. In the performance feedback group, knowledge scores increased from 14.39 to 15.71. Post intervention knowledge scores were significantly better than scores post teaching ($Z = -2.041$, $p = 0.041$). The control groups' knowledge scores deteriorated from 14.00 to 13.81. These were not significantly different to post teaching knowledge scores ($Z = -0.696$, $p = 0.486$). Overall, the performance feedback group had significantly higher knowledge than the control group ($U = 104.000$, $p = 0.029$). For practice, in the performance feedback group, mean observation scores also increased from 12.00 to 16.53. These were significantly better than the scores post teaching ($Z = -3.392$, $p = 0.001$). In contrast, the control group showed a decline from 12.57 to 10.98. These were significantly worse than scores post teaching ($Z = -2.391$,

$p = 0.01$). Overall, the performance feedback group had significantly higher practice scores than the control group ($U = 37.500$, $p < 0.001$).

Hypothesis three predicted that the participants who received performance feedback would demonstrate a greater correspondence between knowledge and practice as a result of having feedback. In the performance feedback group, Kendall's tau was 0.332, which demonstrated a weak to moderate correlation. This did not reach statistical significance ($p = 0.078$). In the control group, Kendall's tau was 0.623 ($p < 0.001$) demonstrating a stronger relationship between knowledge and practice. For many elements of the suctioning procedure, there was a closer association between knowledge and practice than at baseline level. In the performance feedback group, there was an agreement of greater than 80% for 13 out of 19 elements of suctioning. The control group, in contrast had an agreement of greater than 80% for only five elements. In comparison to results at baseline level where agreements of greater than 80% were seen for only eight elements, these findings demonstrate some evidence of the effectiveness of the experimental intervention.

CHAPTER SEVEN: RESULTS FROM THE CLINICAL SETTING

7.1 Introduction

This chapter describes and analyses the findings from the clinical setting. This aspect of the study was conducted at a different inner London teaching hospital and involved nurses and physiotherapists from three HDU's, three respiratory and one ENT ward. Participants were observed suctioning patient's in practice. The observations took place in their own wards or departments. The findings are presented in the following sequence:

7.2 Characteristics of the sample and demographic data

Fifty six subjects participated in the study; 37 nurses and 19 physiotherapists. The majority were female (n = 45, 80%), and aged under 29 (n = 34, 61%). The majority (n = 38, 68%) had less than 5 years post registration experience. More than two thirds of the sample (n = 38, 68%) had previous critical care experience (see Table 7.1).

Table 7.1 Demographic data

Gender n (%)		Profession n (%)		Age range and n (%)		Postregistration experience (years) n (%)		Previous critical care experience n (%)	
Female Male	45 (80) 11 (20)	Nurse Physio	37 (66) 19 (34)	20-24 25-29 > 29	11 (20) 23 (41) 22 (39)	<2 2-5 >5	17 (30) 21 (38) 18 (32)	Yes No	38 (68) 18 (32)

There were no significant differences between the performance feedback or control groups for any of the demographic characteristics ($p > 0.05$).

7.3 Baseline data

7.3.1 Knowledge prior to teaching

At the initial baseline assessment, none of the participants demonstrated complete accuracy in their knowledge base. The maximum score achieved was seventeen, with a median of fifteen. Table 7.2 shows the mean and median scores by group.

Table 7.2 Mean, median and range of scores for knowledge prior to teaching.

Group	Mean	Std Dev	Median	Range
Feedback	11.81	3.026	13.00	4-17
Control	10.79	2.470	11.00	5-15
Overall	11.29	2.775	15.00	4-17

The majority of participants (n = 43, 77%) knew how to adequately prepare the patient prior to suctioning. Similarly, most (n = 49, 87.5%) were aware that hyperoxygenation prior to suctioning is recommended. Only one quarter of participants (n = 14, 25%) thought that the recommended volume of saline to instil prior to suctioning was '0'ml. However, more (n = 22, 39%) indicated that they were aware of the research recommendations and would not routinely use saline. Less than half mentioned hand washing (n = 22, 39%), the need to wear an apron (n = 25, 45%), or protective eye wear (n = 16, 29%). However, the majority (n = 49, 87.5%) stated that gloves would be worn.

Less than half (n = 25, 45%) were aware of the correct size suction catheter to select, with few participants (n = 10, 17%) able to provide a rationale or recommended formula for calculating this. Less than one third (n = 17, 30%) were able to report the recommended suction pressures, and over one third (n = 22, 39%) thought that pressures of 20kpa or above were recommended. Less than a half (n = 24, 43%) reported the recommended duration for suctioning. The majority (n = 48, 86%) reported that they would perform chest auscultation following suctioning and most (n = 46, 82%) were aware of the need to reconnect the oxygen supply within 10 seconds. However, less than two thirds (n = 33, 59%) reported that they would decrease the fraction of inspired oxygen to the previous setting. Only five participants (9%) mentioned the need to wash hands after suctioning, and less than one third (n = 16, 29%) said they would reassure the patient.

There were no significant differences between groups prior to teaching (U = 282.500, p = 0.072). For most aspects there were no statistically significant association between group and knowledge, with the exception of the use of continuous technique. Those in the performance feedback group were more likely to report that they would apply continuous pressure ($\chi2$ = 5.957, df =1, p = 0.015).

7.3.2 Knowledge post teaching (hypothesis one)

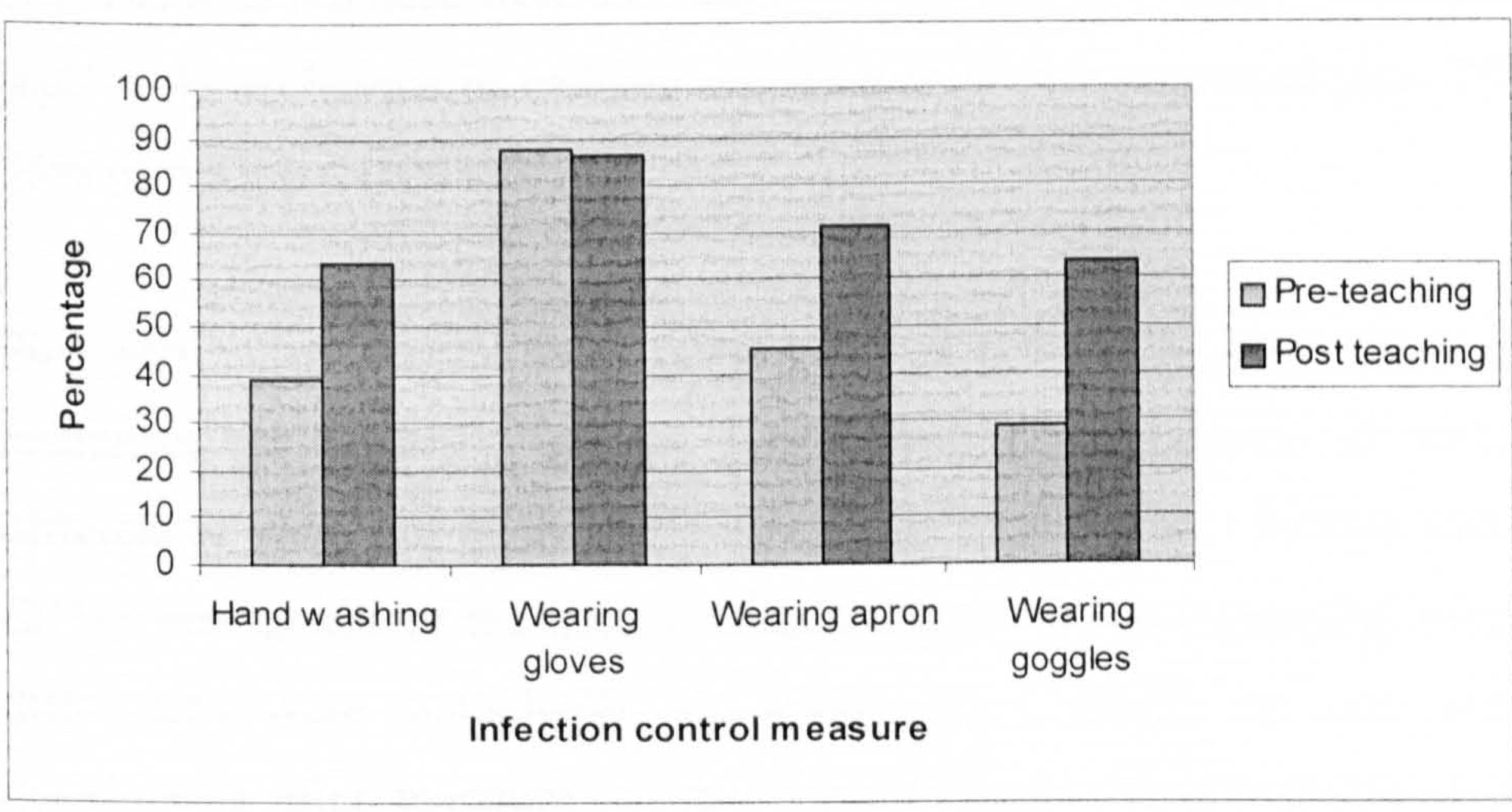
Post teaching knowledge scores were compared with those prior to teaching. Score changes before and after teaching are summarised in Table 7.3. Overall knowledge scores post teaching were significantly better than knowledge prior to teaching (Z = -5.488, p = 0.001). In the performance feedback group, median scores increased from 13.00 to 15.00, and from 11.00 to 15.00 in the control group, as shown in Table 7.3.

Table 7.3 Score changes post teaching.

Group	Mean	Std Dev	Median	Range	Mean/Median Change	
Feedback	14.19	2.602	15	8-19	2.38	2.00
Control	14.31	2.238	15	10-17	3.52	4.00
Overall	14.25	2.339	15	8-19	2.96	3.00

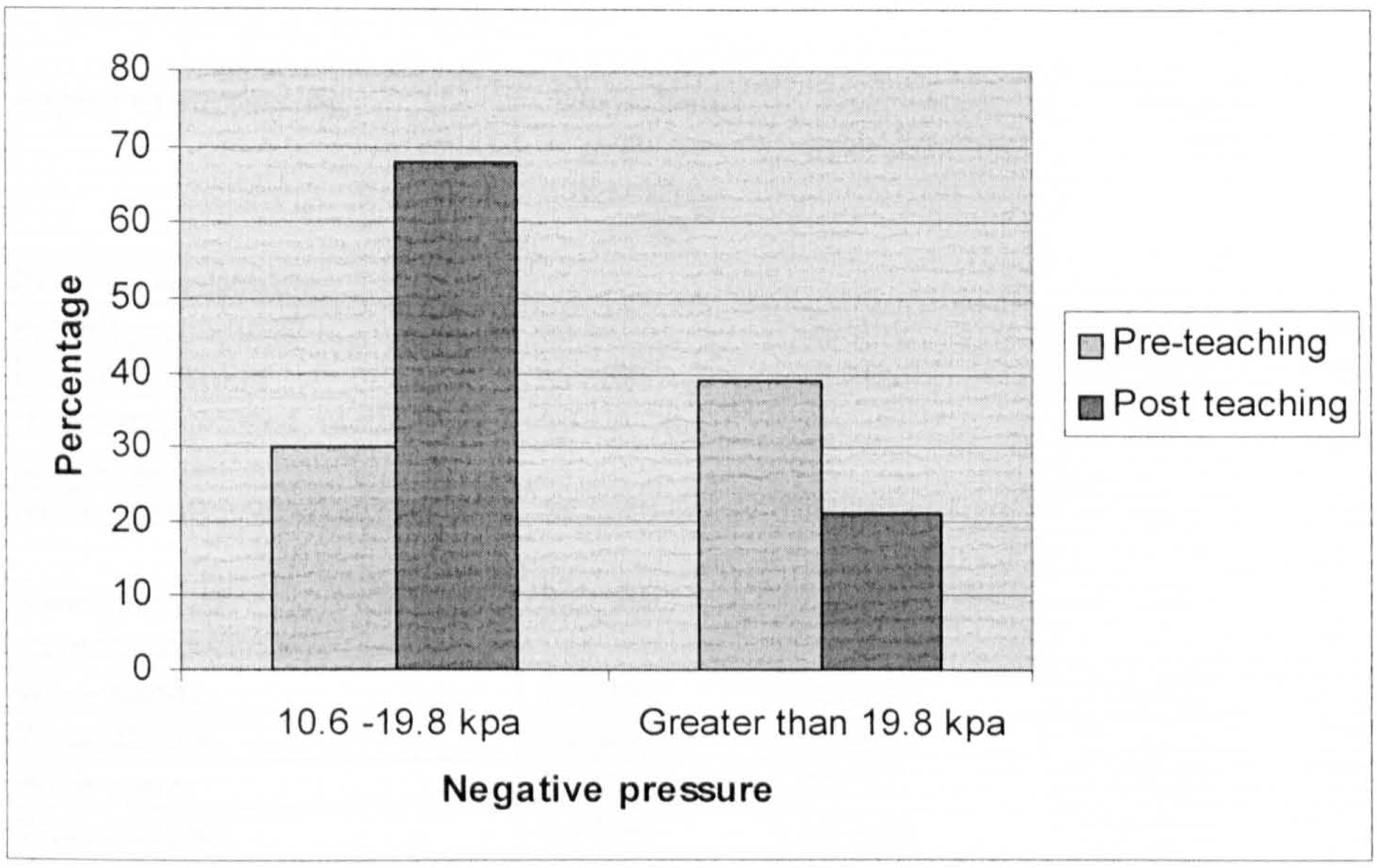
After teaching there was an increase in knowledge for hyperoxygenation. Six more participants (10%) reported that patients should be hyperoxygenated prior to suctioning. These changes were statistically significant ($p = 0.031$). There were also statistically significant changes in relation to infection control, with fourteen more participants (25%, $p = 0.007$) reporting that hands should be washed. Similarly, fifteen more participants (26%, $p = 0.004$) stated that aprons would be worn and twenty more participants (35%) gave eye protection as a response. These differences were highly significant ($p = 0.001$).

Figure 7.1 Knowledge of infection control measures before and after teaching.



The proportion that were aware of the recommended size of suction catheter increased from 45% ($n = 25$) to 77% ($n = 43$). These differences were statistically significant ($p = 0.004$). There were statistically significant changes in relation to knowledge of recommended suction pressures, as this improved from 30% ($n = 17$) to 68% ($n = 38$, $p < 0.001$), although some ($n = 18$, 32%) were still reporting excessively high suction pressures.

Figure 7.2 Knowledge of suctioning pressures before and after teaching



Knowledge of the suctioning technique also improved from 70% (n = 39) to 89% (n = 50). These differences were statistically significant (p = 0.001). Differences were also seen in the technique of catheter withdrawal, as this improved from 75% (n = 42) to 95% (n = 53, p = 0.003).

Post suctioning, several more participants (n = 6, 11%) were aware of the need to reconnect the patient's oxygen supply within ten seconds of suctioning. These differences were not statistically significant (p = 0.070). Twelve more participants (21%) were aware of the need to reduce oxygen to pre suctioning parameters. These differences were statistically significant (p = 0.008). In one area, knowledge deteriorated after teaching. Only 13 participants (23%) mentioned reassuring the patient after suctioning, compared to 16 (29%) at initial baseline level. These differences were not statistically significant (p = 0.581).

Table 7.4 Accuracy of knowledge before and after teaching

Aspect of suctioning	Knowledge prior to teaching *n* (%)	Knowledge post teaching *n* (%)	Change *n* (%)	McNemar p =
Prior to suctioning				
Patient preparation	43 (77)	48 (86)	+5 (9)	p = 0.267
Pre-oxygenation	49 (88)	55 (98)	+6 (10)	**p = 0.031***
If pre-oxygenated, method of pre-oxygenation	49 (100)	55 (100)	0 (0)	p = 1.000
Not to instill normal saline Awareness of recommendations	14 (25) 22 (39)	15 (27) 24 (43)	+1 (2) +2 (5)	p = 1.000
Wash hands	22 (39)	36 (64)	+14 (25)	**P = 0.007****
Wear gloves	49 (88)	48 (86)	-1 (-1)	p = 1.000
Wear apron	25 (45)	40 (71)	+15 (26)	**p = 0.004****
Wear goggles	16 (29)	36 (64)	+20 (35)	**p = 0.001****
During suctioning				
Appropriate sized suction catheter Recommended formula	25 (45) 10 (17)	43 (77) 25 (45)	+18 (32) +15 (28)	**p = 0.004****
Suction pressure of 10.6 – 19.8 kpa	17 (30)	38 (68)	+21 (38)	**p < 0.001****
Application of pressure on withdrawal only	48 (86)	55 (98)	+7 (12)	**P = 0.016***
To use continuous technique	39 (70)	50 (89)	+11 (20)	**p = 0.001****
To withdraw with no lateral movement	42 (75)	53 (95)	+11 (20)	**p = 0.003****
Duration of 10-14 seconds	24 (43)	37 (66)	+13 (23)	**p = 0.007****
To use 3 or fewer suction passes	53 (95)	51 (91)	-2 (4)	p = 1.000
Post suctioning				
Reconnect to oxygen supply within 10 seconds	46 (82)	52 (93)	+6 (11)	p = 0.070
Auscultate chest	48 (86)	53 (95)	+5 (9)	p = 0.125
Wash hands	5 (9)	9 (16)	+4 (7)	p = 0.219
Reassure patient	16 (29)	13 (23)**	-3 (6)	p = 0.581
Return oxygen flow to previous setting	33 (59)	45 (80)	+12 (21)	**P = 0.008****

* Indicates significance at the 5% level
** Indicates significance at the 1% level

There were no significant differences between the performance feedback and control groups after initial teaching (U = 368.000, p = 0.697). There were no significant differences between group and knowledge of individual aspects of the suctioning procedure with the exception of verbal reassurance. Participants in the performance feedback group were less likely to report that they would reassure the patient post suctioning ($\chi 2$ = 4.285, df = 1, p = 0.038). However, in view of the number of comparisons and lack of overall difference a single significant result is unsurprising.

It would therefore appear that the groups were equivalent prior to the commencement of the experimental intervention.

7.3.3 Correspondence between knowledge with practice post teaching

None of the participants demonstrated complete accuracy for all aspects of the suctioning procedure. Scores ranged from 9.5 to 19. Table 7.5 shows the average score post teaching by group. Kendall's tau was 0.233 ($p = 0.019$), which indicated that there was a weak correlation between knowledge and practice post teaching.

Table 7.5 Correspondence between knowledge and practice post teaching

Group	Knowledge:				Practice:			
	Mean	Std Dev	Median	Range	Mean	Std Dev	Median	Range
Feedback	14.19	2.602	15.00	8.00-19.00	14.20	2.237	14.00	11.00-19.00
Control	14.31	2.238	15.00	10.00-17.00	13.87	2.234	14.00	9.50-18.50
Overall	14.25	2.339	15.00	8.00-19.00	14.03	2.221	14.00	9.50-19.00

Table 7.7 shows the proportions complying with the research recommendations when observed in practice, and how practice corresponded with knowledge.

Table 7.6 Knowledge of recommendations compared to practice

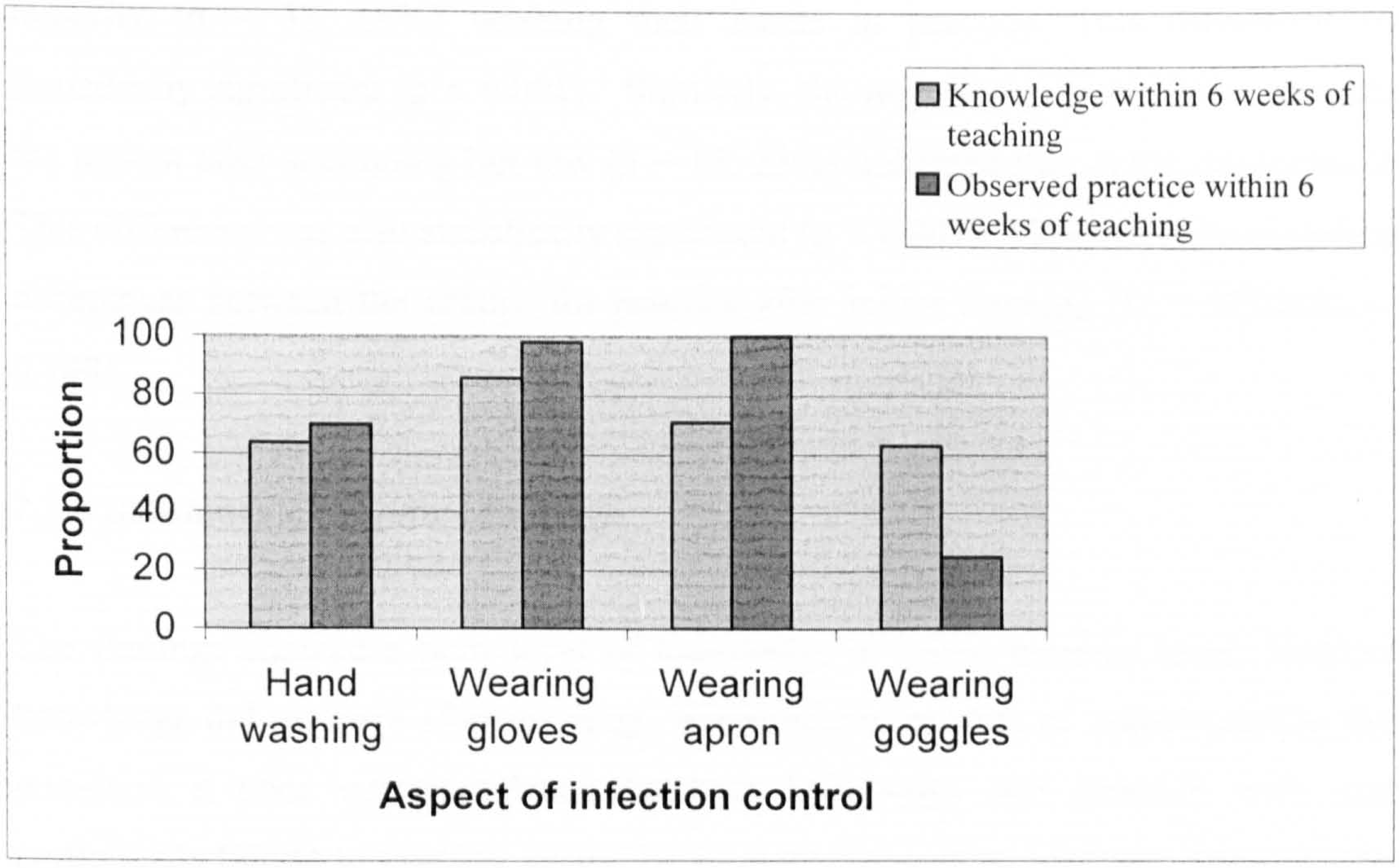
Aspect of suctioning	Knowledge *n* (%)	Practice *n* (%)	% agreement	McNemar p=
Prior to suctioning				
Patient preparation	48 (86)	47 (84)	98	p = 1.000
Pre-oxygenation	55 (98)	23 (41)	42	p < 0.001 **
If pre-oxygenated, method of pre-oxygenation	55 (100)	23 (100)	100	p = 1.000
Awareness of recommendation not to instill saline	24 (43)	54 (96)	44	P < 0.001 **
Wash hands	36 (64)	39 (70)	92	p = 0.664
Wear gloves	48 (86)	55 (98)	87	p = 0.039 *
Wear apron	40 (71)	56 (100)	71	P < 0.001 **
Wear goggles	36 (64)	14 (25)	39	P < 0.001 **
During suctioning				
Appropriate sized suction catheter	43 (77)	24 (43)	56	p = 0.002 **
Suction pressure of 10.6 – 19.8 kpa	38 (68)	9 (16)	24	p < 0.001 **
Application of pressure on withdrawal only	55 (98)	54 (96)	98	p = 1.000
To use continuous technique	50 (89)	50 (89)	100	p = 1.000
To withdraw with no lateral movement	53 (95)	47 (84)	89	p = 0.070
Duration of 10-14 seconds	37 (66)	16 (29)	43	P < 0.001 **
To use 3 or fewer suction passes	51 (91)	56 (100)	91	p = 0.125
Post suctioning				
Reconnect to oxygen supply within 10 seconds	52 (93)	48 (89)	96	p = 0.754
Auscultate chest	53 (95)	17 (30)	32	p < 0.001 **
Wash hands	9 (16)	38 (68)	24	p < 0.001 **
Reassure patient	13 (23)	41 (73)	32	p < 0.001 **
Return oxygen flow to previous setting	45 (80)	19 (83)	42	p = 1.000

* Indicates significance at the 5% level
** Indicates significance at the 1% level

The majority of participants were aware that hyperoxygenation is recommended (n = 55, 98%), but less than half (n = 23, 41%) hyperoxygenated in practice. These differences were statistically significant ($p < 0.001$). Although knowledge of saline recommendations was generally poor, 43% (n = 24) the majority (n = 54, 96%) did not instil saline in practice. These differences were statistically significant ($p < 0.001$).

There were significant differences in relation to most aspects of infection control. Almost two thirds (n = 36, 64%) were aware that eye protection should be worn but few (n = 14, 25%) wore goggles in practice. These differences were statistically significant ($p < 0.001$). Statistically significant differences were also seen for the use of gloves ($p = 0.039$) and aprons ($p < 0.001$), although for these aspects, practice was an improvement on knowledge.

Figure 7.3 Comparison of proportions aware of infection control measures and the proportions who complied with recommendations in practice



There were statistically significant differences between knowledge and practice for other aspects of suctioning. Although the majority ($n = 43$, 77%) were aware of the appropriate sized suction catheter to use, less than half ($n = 24$, 43%) used a correct size in practice. This difference was statistically significant ($p = 0.002$) More than two thirds ($n = 38$, 68%) were aware of the appropriate suction pressures but only nine (16%) suctioned using the recommended pressure in practice. This difference was statistically significant ($p < 0.001$). Two thirds ($n = 37$, 66%) had knowledge of the recommended time frame for suctioning, but few ($n = 9$, 16%) implemented this in practice. This difference was also statistically significant ($p < 0.001$).

Post suctioning, there was a good correspondence for reconnecting the patient's oxygen supply but not for other aspects. Few ($n = 17$, 30%) performed chest auscultation in practice, although almost all ($n = 53$, 95%) were aware that this is recommended practice. This difference was statistically significant ($p < 0.001$). For hand washing post suctioning, practice was an improvement on knowledge, with the majority ($n = 38$, 68%) washing their hands in practice. This difference was statistically significant ($p < 0.001$). Similarly, the majority ($n = 41$, 73%) reassured the patient after suctioning but few ($n = 12$, 23%) indicated this in the questionnaire. This difference was also statistically significant ($p < 0.001$). There were no significant differences between the groups for practice after initial teaching ($U = 372.000$, $p = 0.748$).

7.3.4 Summary of baseline findings

The findings showed a poor level of knowledge at initial baseline level. However, knowledge did improve after teaching. Nevertheless, in spite of improvements, there remained a poor correspondence between knowledge and practice with many participants failing to practice according to current recommendations. These findings were consistent across the two groups, and many are consistent with the findings from the simulation setting.

7.4 Effectiveness of experimental intervention

7.4.1 Knowledge post intervention

In the performance feedback group, mean knowledge scores increased from 14.19 to 15.46. Post intervention scores were significantly better than post teaching scores ($Z = -2.449$, $p = 0.014$). The control group's mean knowledge scores improved slightly from 14.31 to 14.41 (Table 7.7). These were not significantly different to post teaching scores ($Z = -0.066$, $p = 0.948$). Overall, there were no statistically significant differences between the performance feedback and control groups knowledge scores post intervention ($U = 287.000$, $p = 0.187$).

Table 7.7 Scores changes post intervention.

Group	Mean	Std Dev	Median	Range	Mean/Median Change	
Feedback	15.46	1.749	15.00	11.00-20.00	+1.27	0
Control	14.41	2.500	15.00	10.00-18.00	+0.10	0
Overall	14.92	2.209	15.00	10.00-20.00	+0.67	0

In the performance feedback group, knowledge improved in 13 out of 20 elements of suctioning, remained unchanged in one element and deteriorated in the remaining six elements. The control group's knowledge improved in four elements, remained unchanged for three elements and deteriorated in the remaining 13 elements. None of the differences were statistically significant.

Table 7.8 Accuracy of knowledge post intervention

Aspect of suctioning	Post teaching *n* (%)	Post intervention *n* (%)	Change	Difference %	McNemar p=
Prior to suctioning					
Patient preparation					
Feedback	24 (89)	22 (85)	-2 (-4)*	+1	p = 1.000
Control	24 (83)	21 (78)	-3 (-5)*		p = 1.000
Pre-oxygenation					
Feedback	26 (96)	25 (96)	0 (0)	0	p = 1.000
Control	29 (100)	27 (100)	0 (0)		p = 1.000
Saline recommendations					
Feedback	6 (24)	11 (46)	+5 (+22)	+26	p = 0.125
Control	9 (32)	7 (28)	-2 (-4)		p = 1.000
Wash hands					
Feedback	15 (56)	20 (77)	+5 (+21)	+21	p = 0.070
Control	21 (72)	21 (78)	0 (0)		p = 1.000
Wear gloves					
Feedback	22 (81)	25 (96)	+4(+15)	+20	p = 0.375
Control	26 (90)	23 (85)	-3 (-5)*		p= 1.000
Wear apron					
Feedback	18 (67)	20 (77)	+2 (+10)	+8	p = 0.453
Control	22 (76)	21 (78)	+2 (+2)		P = 1.000
Wear goggles					
Feedback	18 (67)	22 (85)	+4 (+18)	+18	p = 0.125
Control	17 (59)	16 (59)	-1 (0)		p = 1.000
During suctioning					
Appropriate sized catheter					
Feedback					p = 1.000
Control	24 (89)	23 (88)	-1 (-1)	+3	p = 1.000
Stated recommended	19 (65)	16 (61)	-3 (-4)		
formula/rationale					
Feedback	14 (52)	15 (58)	+1(+6)	+14	p = 0.250
Control	11 (38)	8 (30)	-3 (-8)		p = 1.000
Correct suction pressures					
Feedback	17 (63)	18 (69)	+1 (+6)	+19	p = 0.727
Control	21 (72)	16 (59)	-5 (-13)		p = 0.344
Pressure on withdrawal only					
Feedback	27 (100)	24 (92)	-3 (-8)	-7	p = 0.500
Control	28 (97)	26 (96)	-2 (-1)		p = 1.000
To use continuous technique					
Feedback	26 (96)	24 (92)	-2 (-4)	-2	p = 1.000
Control	24 (83)	23 (85)	-1 (-2)		p = 1.000
No lateral movement					
Feedback	26 (96)	25 (96)	+1 (0)	-7	p = 1.000
Control	27 (93)	27 (100)	0 (+7)		p = 1.000
Duration of 10-14 seconds					
Feedback	17 (63)	17 (65)	0 (+2)	+3	p = 1.000
Control	20 (69)	19 (70)	-1 (-1)		p = 1.000
3 or less suction passes					
Feedback	25 (93)	24 (96)	-1 (-3)	-3	p = 1.000
Control	26 (93)	25 (93)	-1 (0)		p = 1.000
Post suctioning					
Reconnect within 10 seconds					
Feedback	24 (89)	24 (92)	0 (+3)	+10	p = 1.000
Control	28 (97)	24 (90)	-4 (-7)		p = 0.500
Auscultate chest					
Feedback	24 (90)	23 (88)	-1 (-2)	-2	p = 1.000
Control	29 (100)	27 (100)	0 (0)		p = 1.000
Wash hands					
Feedback	3 (11)	7 (27)	+4 (+16)	+15	p = 0.219
Control	6 (21)	6 (22)	0 (+1)		p = 1.000
Reassure patient					
Feedback	3 (11)	8 (31)	+5 (+20)	+21	p = 0.125
Control	10 (34)	9 (33)	-1 (-1)		p = 1.000
Return oxygen flow to previous setting					
Feedback	23 (85)	23 (92)	0 (+7)	+2	p = 1.000
Control	22 (76)	22 (81)	0 (+5)		p = 1.000

7.4.2 Practice post intervention

In the performance feedback group, mean practice scores increased from 14.20 to 16.04. Post intervention practice scores were significantly better than post teaching scores ($Z = -3.372$, $p = 0.001$). The control groups' practice scores also increased slightly, from 13.87 to 14.58, although the improvements were not statistically significant ($Z = -1.332$, $p = 0.183$). Overall, the performance feedback group had significantly higher practice scores than the control group ($U = 187.000$, $p = 0.037$).

Table 7.9 Score changes post feedback.

Group	Mean	Std Dev	Median	Range	Mean/Median Change	
Feedback	16.04	2.245	16.00	12.00-19.00	+1.84	+2.00
Control	14.58	2.266	14.50	11.00-19.00	+0.710	+0.50
Overall	15.28	2.35	15.00	11.00-19.00	+1.25	+1.00

In the performance feedback group, practice improved in 14 out of 19 elements of suctioning, and remained unchanged for two elements. In the remaining three areas, practice deteriorated. The control group's practice improved in 11 elements, deteriorated in five and remained unchanged for three elements (Table 7.10).

In the performance feedback group, improvements were seen for hand washing, with two more participants washing their hands before suctioning. These differences were not statistically significant ($p = 0.375$). In the control group, six more subjects were observed washing their hands before suctioning. These differences were statistically significant ($p = 0.004$). Statistically significant differences were seen in the performance feedback group for the use of correct suction pressures ($p = 0.004$), with eight more participants complying with research recommendations. In the control group, practice remained unchanged. In the performance feedback group, there were slight changes with auscultation post suctioning, with more participants ($n = 3$, 16%) performing auscultation in practice. This did not reach statistical significance ($p = 0.219$). In the control group, seven more participants (29%) performed chest auscultation. This difference was statistically significant ($p = 0.016$). Statistically significant differences were also seen in the performance feedback group for hand washing, with four more (29%) participants washing their hands after suctioning ($p = 0.039$). The control group remained unchanged ($p = 1.000$)

Table 7.10 Accuracy of practice post intervention

Aspect of suctioning	Post teaching *n* (%)	Post intervention *n* (%)	Change	Difference %	McNemar p=
Prior to suctioning					
Patient preparation					
Feedback	21 (84)	23 (100)	+2 (+16)	-12	p = 0.250
Control	21 (72)	25 (100)	+4 (+28)		p = 0.063
Pre-oxygenation					
Feedback	12 (48)	15 (65)	+3 (+17)	+19	p = 0.289
Control	11 (38)	9 (36)	-2 (-2)		p = 1.000
Saline recommendations					
Feedback	23 (92)	23 (100)	0 (+8)	+8	p = 1.000
Control	29 (100)	25 (100)	0 (0)		p = 1.000
Wash hands					
Feedback	20 (80)	22 (96)	+2 (+16)	-17	p = 0.375
Control	17 (59)	23 (92)	+6 (+33)		**p = 0.004 ****
Wear gloves					
Feedback	24 (96)	23 (100)	+1 (+4)	+4	p = 1.000
Control	29 (100)	25 (100)	0 (0)		p = 1.000
Wear apron					
Feedback	25 (100)	23 (100)	0 (0)	+4	p = 0.500
Control	29 (100)	24 (96)	-5 (-4)		p = 1.000
Wear goggles					
Feedback	8 (32)	9 (39)	+1 (+7)	0	p = 0.508
Control	6 (21)	7 (28)	+1 (+7)		p = 0.500
During suctioning					
Appropriate sized catheter					
Feedback	12 (48)	15 (65)	+3 (+17)	+7	p = 0.424
Control	11 (38)	12 (48)	+1 (+10)		p = 0.815
Correct suction pressures					
Feedback	3 (12)	11 (48)	+8 (+36)	+33	**p = 0.004 ****
Control	6 (21)	6 (24)	0 (+3)		p = 0.705
Application of pressure on withdrawal only					
Feedback	25 (100)	22 (96)	-3 (-4)	-1	p = 1.000
Control	28 (97)	25 (100)	+3 (+3)		p = 1.000
Continuous technique					
Feedback	24 (96)	20 (87)	-4 (-9)	-3	p = 0.625
Control	25 (86)	23 (92)	-2 (-6)		p = 1.000
No lateral movement					
Feedback	22 (88)	22 (96)	0 (+8)	+13	p = 1.000
Control	23 (79)	21 (84)	-2 (-5)		p = 0.754
Duration 10-14 seconds					
Feedback	7 (28)	10 (44)	+3 (+16)	+12	p = 0.206
Control	8 (28)	8 (32)	0 (+4)		p = 1.000
3 or less suction passes					
Feedback	25 (100)	23 (100)	0 (0)	0	p = 1.000
Control	29 (100)	25 (100)	0 (0)		p = 1.000
Post suctioning					
Reconnect to oxygen supply within 10 seconds					
Feedback	20 (83)	19 (83)	-1 (0)	-2	p = 1.000
Control	27 (93)	21 (95)	+6 (+2)		p = 1.000
Auscultate chest					
Feedback	9 (36)	12 (52)	+3 (+16)	-13	p = 0.219
Control	7 (24)	13 (53)	+6 (+29)		**p = 0.016 ***
Wash hands					
Feedback	18 (67)	22 (96)	+4 (+29)	+18	**p = 0.039***
Control	20 (69)	20 (80)	0 (+11)		p = 0.508
Reassure patient					
Feedback	18 (72)	19 (83)	+1 (+9)	+5	p = 0.508
Control	21 (72)	19 (76)	+2 (+4)		p = 1.000
Return oxygen to previous setting					
Feedback	11 (92)	13 (87)	+2 (+5)	+11	p = 1.000
Control	8 (73)	6 (67)	-2 (-6)		p = 1.000

* Indicates significance at the 5% level
** Indicates significance at the 1% level

7.4.3 Correspondence between knowledge and practice post intervention

Following the experimental intervention, there were few elements of suctioning with a strong correspondence between knowledge and practice. Greater improvements were seen in the participant's practice scores when compared to knowledge. Table 7.11 shows the comparison of scores for knowledge and practice by group. In the performance feedback group, Kendall's tau was 0.045, which demonstrated a small correlation between knowledge and practice ($p = 0.783$). In the control group, Kendall's tau was 0.065, which also demonstrated a small correlation ($p = 0.646$).

Table 7.11 Correspondence between knowledge and practice post intervention

Group	Knowledge post feedback:		Practice post feedback:		Range	
	Mean	Median	Mean	Median	Knowledge	Practice
Feedback	15.46	15.00	16.04	16.00	11-20	12-19
Control	14.41	15.00	15.58	14.50	10-18	11-19
Overall	14.92	15.00	15.28	15.00	10-20	11-19

For both groups, there was an agreement of more than 80% for only eight elements of suctioning. Significant differences were seen for hyperoxygenation. In the performance feedback group, most (n = 25, 96%) were aware of recommendations but few (n = 15, 65%) complied in practice. This difference was statistically significant ($p = 0.016$). Similarly, in the control group, all (n = 27, 100%) were aware of recommendations but few (n = 9, 36%) complied in practice. This difference was statistically significant ($p < 0.001$). There were also differences between knowledge and practice for the use of protective eye-wear. In the performance feedback group, many participants (n = 22, 85%) were aware that goggles should be worn but few (n = 9, 39%) wore goggles in practice. This difference was statistically significant ($p = 0.013$). In the control group, just over half (n = 16, 59%) had knowledge of recommendations but few (n = 7, 28%) complied in practice. This difference was also statistically significant ($p = 0.008$).

Statistically significant differences were also seen for use of the correct suction pressures. In the performance feedback group, 18 participants (69%) had knowledge of recommendations but less ($n = 11$, 48%) complied in practice. This difference was not statistically significant ($p = 0.125$). In the control group, 16 participants (59%) demonstrated knowledge of recommendations but few ($n = 2$, 24%) used correct pressures in practice. This difference was statistically significant ($p = 0.012$). Significant differences were also seen in the control group for duration of the procedure, with few ($n = 8$, 32%) suctioning within the correct time frame ($p = 0.049$). In the performance feedback group, many participants ($n = 23$, 88%) had knowledge of chest auscultation but not all ($n = 12$, 52%) performed auscultation in practice. This difference was statistically significant ($p = 0.008$). In the control group, all ($n = 27$, 100%) had knowledge of recommendations but only 13 (53%) complied in practice. This difference was highly significant ($p < 0.001$).

For several elements of suctioning, practice was a significant improvement on knowledge. In the performance feedback group, only 11 (46%) participants were aware that saline should not be used but none ($n = 23$, 100%) instilled saline in practice ($p < 0.001$). Similarly, in the control group, few ($n = 7$, 28%) had knowledge of recommendations but no participants ($n = 25$, 100%) used saline in practice ($p < 0.001$). For both groups, significant differences were seen for hand washing post suctioning and providing verbal reassurance to the patient, as illustrated in Table 7.12.

Table 7.12 Correspondence between knowledge and practice post intervention

Aspect of suctioning	Knowledge post feedback *n* (%)	Practice post feedback *n* (%)	Percent agreement	McNemar p =
Prior to suctioning				
Patient preparation				
Feedback	22 (85)	23 (100)	96	p = 0.250
Control	21 (78)	25 (100)	84	p = 0.063
Pre-oxygenation				
Feedback	25 (96)	15 (65)	60	**p = 0.016 ***
Control	27 (100)	9 (36)	33	**p < 0.001 ****
Saline recommendations				
Feedback	11 (46)	23 (100)	48	**p < 0.001 ****
Control	7 (28)	25 (100)	28	**p < 0.001 ****
Wash hands				
Feedback	20 (77)	22 (96)	91	p = 0.375
Control	21 (78)	23 (92)	91	p = 0.375
Wear gloves				
Feedback	25 (96)	23 (100)	92	p = 1.000
Control	23 (85)	25 (100)	92	p = 0.250
Wear apron				
Feedback	20 (77)	23 (100)	87	p = 0.219
Control	21 (78)	24 (96)	87	p = 0.125
Wear goggles				
Feedback	22 (85)	9 (39)	41	**p = 0.013 ***
Control	16 (59)	7 (28)	44	**p = 0.008 ****
During suctioning				
Appropriate sized suction catheter				
Feedback	23 (88)	15 (65)	70	p = 0.070
Control	16 (61)	12 (48)	75	p = 0.607
Correct suction pressures				
Feedback	18 (69)	11 (48)	61	p = 0.125
Control	16 (59)	6 (24)	38	**p = 0.012 ***
Application of pressure on withdrawal only				
Feedback	24 (92)	22 (96)	92	p = 1.000
Control	26 (96)	25 (100)	96	p = 0.500
Continuous technique				
Feedback	24 (92)	20 (87)	83	p = 0.500
Control	23 (85)	23 (92)	100	p = 1.000
To withdraw with no lateral movement				
Feedback	25 (96)	22 (96)	88	p = 1.000
Control	27 (100)	21 (84)	78	p = 0.125
Duration of 10-14 seconds				
Feedback	17 (65)	10 (44)	59	p = 0.092
Control	19 (70)	8 (32)	42	**p = 0.049 ***
To use 3 or fewer suction passes				
Feedback	24 (96)	23 (100)	96	p = 1.000
Control	25 (93)	25 (100)	100	p = 1.000
Post suctioning				
Reconnect to oxygen supply within 10 seconds				
Feedback	24 (92)	19 (83)	79	p = 0.625
Control	24 (90)	21 (95)	84	p = 0.500
Auscultate chest				
Feedback	23 (88)	12 (52)	52	**p = 0.008 ****
Control	27 (100)	13 (53)	48	**p < 0.001 ****
Wash hands				
Feedback	7 (27)	22 (96)	32	**p < 0.001 ****
Control	6 (22)	20 (80)	30	**p = 0.001 ****
Reassure patient				
Feedback	8 (31)	19 (83)	42	**p = 0.001 ****
Control	9 (33)	19 (76)	47	**p = 0.003 ****
Return oxygen flow to previous setting				
Feedback	23 (92)	13 (87)	56	p = 0.500
Control	22 (81)	6 (67)	27	p = 0.250

* Indicates significance at the 5% level
** Indicates significance at the 1% level

7.5 Chapter summary

This chapter has presented the findings in a clinical setting. Prior to initial teaching, none of the participants demonstrated complete accuracy in their knowledge base for all aspects of tracheal suctioning. Scores ranged from four to 17, and there were no significant differences between the performance feedback and control groups ($U = 282.500$, $p = 0.072$). Specific areas of concern were very similar to the simulation study; reported use of normal saline, poor knowledge of infection control practices, inappropriate catheter selection and excessive suction pressures.

Hypothesis one predicted that, following the standard teaching programme, the participants would demonstrate a higher level of knowledge. Slight improvements were seen in the knowledge scores after conventional teaching. Scores ranged from eight to 19, and there were no significant differences between the performance feedback and control groups ($U = 368.000$, $p = 0.697$). Concerns remained over use of saline, inappropriate catheter selection and excessive suction pressures. For practice, none of the participants demonstrated complete accuracy in their suctioning techniques after conventional teaching. Scores ranged from 9.50 to 19.00 and there were no significant differences between groups ($U = 372.000$, $p = 0.748$). Specific areas of concern were very similar to the simulation study; non-adherence to infection control recommendations, especially protective eye wear, excessive suction pressures and limited use of hyperoxygenation.

Hypothesis two predicted that the subjects who received performance feedback would improve and sustain a higher level of knowledge and practice as a result of having feedback. In the performance feedback group, knowledge scores increased from 14.19 to 15.46. Post intervention knowledge scores were significantly better than post teaching scores ($Z = -2.449$, $p = 0.014$). In the control group, scores increased from 14.31 to 14.41, although the improvements were not statistically significant ($Z = -0.066$, $p = 0.948$). Overall, there were no statistically significant differences between the performance feedback and control groups knowledge scores post intervention ($U = 287.000$, $p = 0.187$).

For practice, the performance feedback group's mean observation scores increased from 14.20 to 16.04. Post intervention practice scores were significantly better that post teaching scores ($Z = -3.372$, $p = 0.001$). The control groups' scores increased from 13.87 to 14.58, although the improvement was not statistically significant ($Z = -1.332$, $p = 0.183$). Overall, the performance feedback group had significantly higher practice scores than the control group ($U = 187.000$, $p = 0.037$).

Hypothesis three predicted that the participants who received performance feedback would demonstrate a closer correspondence between knowledge and practice. In the performance feedback group, Kendall's tau was 0.045, demonstrating a small correlation between knowledge and practice. This was not statistically significant ($p = 0.783$). This could have been a result of greater improvements in the participants practice scores when compared to knowledge. In the control group, Kendall's tau was 0.018. This was not statistically significant ($p = 0.905$). There were few elements of the suctioning procedure where there was a strong association between knowledge and practice. In the performance feedback group, there was an agreement of over 80% for only eight elements, compared to the control group of only four elements. The findings show a weaker association between knowledge and practice compared to the simulation setting.

CHAPTER EIGHT: RESULTS FROM THE MERGED DATA

8.1 Introduction

In order to explore the similarities and differences in the effects of the intervention across the two settings and two professions, the two data sets were subsequently merged and an analysis of variance model applied. A three-way ANOVA was used to explore the overall effect of groups, settings, and profession on both knowledge and practice. All two and three way interactions between the main effects were also tested in order to determine whether, for example, the effect of the intervention varied between settings or professions. This process also made it possible to test the overall effectiveness of the intervention with a larger sample size, which increased the power of the study. The findings are presented in the following sequence:

8.2 Relationships between groups, professions and settings

8.1.1 Knowledge
8.1.2 Practice

8.3 Correspondence between knowledge and practice (Hypothesis 3)

8.4 Chapter summary

8.2 Relationships between groups, professions and settings

8.2.1 Knowledge

Table 8.1: Three-way ANOVA for knowledge post intervention

Source	DF	SS	MS	F	p
Group	1	4342.423	4342.423	8.539	0.004**
Profession	1	6.739	6.739	0.013	0.909
Setting	1	99.999	99.999	0.197	0.659
Group*Profession	1	201.628	201.628	0.396	0.531
Setting*Group	1	113.491	113.491	0.223	0.638
Setting*Profession	1	1402.383	1402.303	2.758	0.101
Setting*Group*Profession	1	478.450	478.450	0.941	0.335

** Indicates significance at the 1% level

Three-way ANOVA (Table 8.1) showed that the performance feedback group's knowledge post intervention was significantly better than the control group ($F = 8.539$, df 1, $p = 0.004$). There were no statistically significant differences between the two professions ($p = 0.909$) or between the settings ($p = 0.659$). There were no statistically significant interactions between the groups and settings ($p = 0.638$), the groups and professions ($p = 0.531$) or the professions and the settings ($p = 0.101$), indicating that the effect of the intervention did not differ between the professions or across the settings (see Table 8.2 for individual group means).

Table 8.2 Knowledge across settings by profession and intervention group

Setting	Performance Feedback:		Control:	
	Nurse	Physiotherapist	Nurse	Physiotherapist
Simulation	15.82	15.50	13.21	15.00
Clinical	15.22	16.00	14.81	13.82

8.2.2 Practice

Table 8.3 Three-way ANOVA for practice post intervention

Source	DF	SS	MS	F	p
Group	1	13749.861	13749.861	47.352	**0.001****
Profession	1	2646.807	2646.807	9.115	**0.003****
Settings	1	411.530	411.530	1.417	0.238
Group*Profession	1	242.940	240.940	0.837	0.363
Group*Settings	1	4814.134	4814.134	16.579	**0.001****
Setting*Profession	1	845.174	845.174	2.911	0.092
Setting*Group*Profession	1	247.562	247.562	0.853	0.359

* Indicates significance at the 5% level
** Indicates significance at the 1% level

Three-way ANOVA (Table 8.3) also showed that the performance feedback group's practice post intervention was significantly better than the control group ($F = 47.352$, df 1, $p < 0.001$). Statistically significant differences were also seen between the professions, with physiotherapists performing better than nurses ($F = 9.115$, df 1, $p = 0.003$). There were no statistically significant interactions between the groups and professions ($p = 0.363$) or professions and settings ($p = 0.092$). However, statistically significant interactions were found between the groups and settings for practice ($F = 16.579$, df 1, $p < 0.001$), demonstrating that the effect of the intervention differed between settings.

The significant interaction stems primarily from a much larger effect of the intervention being apparent in the simulation setting. This is due to the both superior performance of the control group in the clinical setting compared to the simulation setting and to a lesser extent relatively poorer performance in the intervention group in the clinical setting compared to the simulation setting. Figure 8.1 presents the estimated marginal means for the performance feedback and control groups ranked practice scores across the two settings and Table 8.4 gives the raw score means.

Figure 8.1: Estimated marginal means of (ranked) practice scores

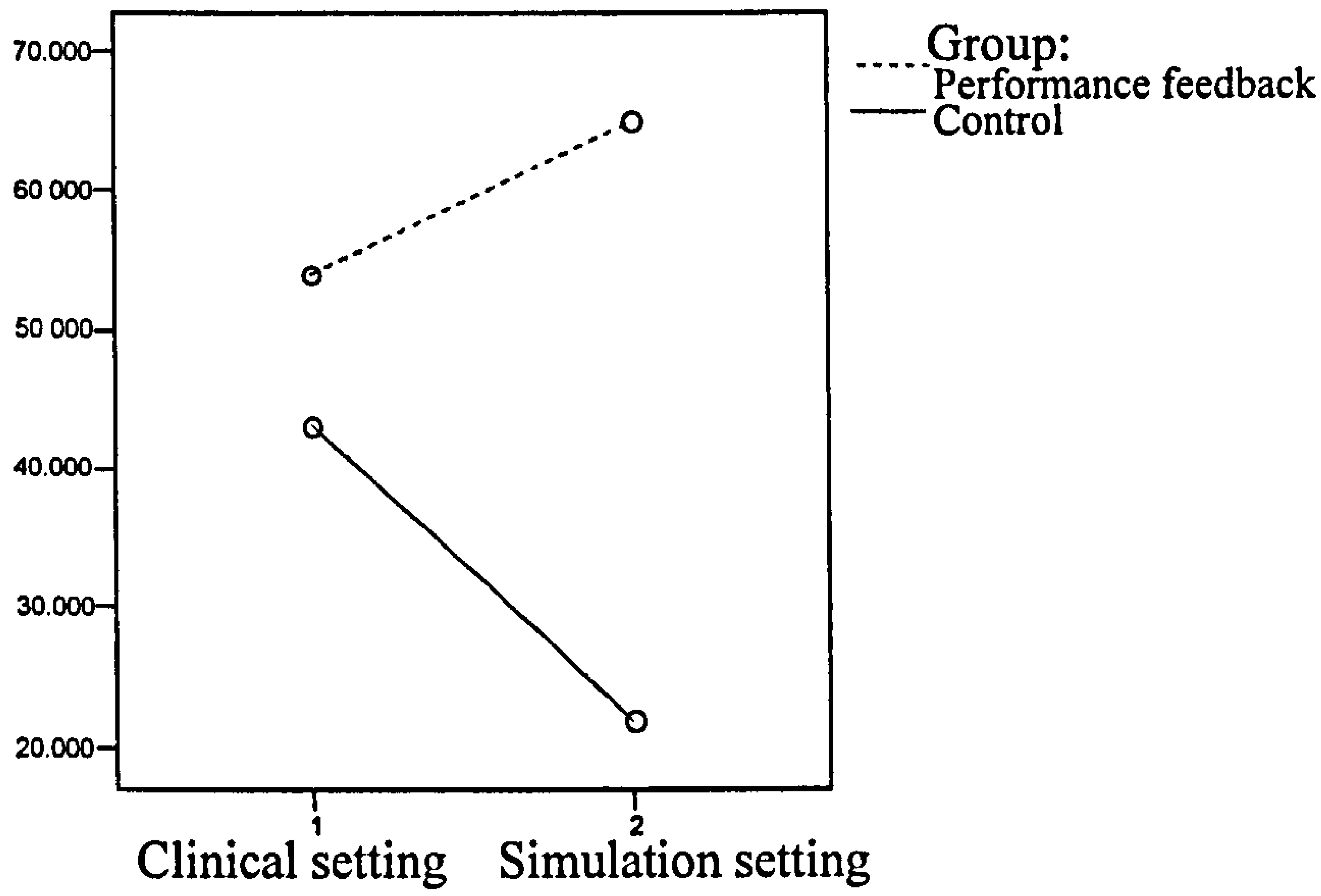


Table 8.4 Practice across settings by profession and intervention group

Setting	Performance Feedback: Nurse	Physiotherapist	Control: Nurse	Physiotherapist
Simulation	16.45	16.67	10.64	11.64
Clinical	15.44	17.42	13.37	16.40

8.3 Correspondence between knowledge and practice post intervention

The correspondence between knowledge and practice remained weak in both the performance feedback (Kendall's tau 0.227) and control group (Kendall's tau 0.226) and indeed was weaker than before the intervention. This weaker correspondence between knowledge and practice post intervention for the intervention group may be a result of greater improvements in practice compared to knowledge (Table 8.5).

Table 8.5 Correspondence between knowledge and practice post intervention

Group	Knowledge: Mean	Std Dev	Median	Range	Practice: Mean	Std Dev	Median	Range
Feedback	15.56	1.931	16.00	11.00-20.00	16.25	2.636	16.75	8.50-19.50
Control	14.15	2.634	15.00	5.00-18.00	12.93	3.212	13.25	4.00-19.00
Overall	14.81	2.422	15.00	5.00-20.00	14.47	3.378	15.00	4.00-19.50

8.4 Chapter summary

This chapter has compared the findings from both the clinical and simulation settings. The purpose of amalgamating the data was to explore the similarities and differences within the sample, the professions and the settings. Following the experimental intervention, the performance feedback group's knowledge improved, whereas the control groups deteriorated. The performance feedback group's knowledge was significantly better than the control group. Three-way ANOVA showed no statistically significant interactions between the groups, settings or professions, which demonstrated that the effect was the same.

Practice also improved post intervention. Three-way ANOVA showed that the performance feedback group's practice post intervention was significantly better than the control group There were also statistically significant differences between the professions, with physiotherapists performing better than nurses overall, although this effect was not the same across settings. Statistically significant interactions were found between the groups and settings, which showed that the effect of the intervention differed across settings, with participants in the simulation setting's performance feedback group performing better than those in the clinical setting. In spite of improvements in knowledge and performance, the correspondence between knowledge and practice post intervention deteriorated for both groups in both settings. This was thought to be due to the performance feedback having a greater impact on practice than knowledge.

CHAPTER NINE: DISCUSSION

9.1 Introduction

The findings of this study have raised some interesting issues relating to all aspects of education and its impact on tracheal suctioning practices. The two research methods employed were successful in generating information that was comparable and amenable to statistical analysis. Some interesting issues pertaining to the different settings and the use of simulation as a research strategy have also emerged, and key differences between professional groups are identified. This chapter is organised into the following sections;

9.1.1 Effectiveness of conventional teaching (Hypothesis 1)
9.1.2 Effectiveness of experimental intervention (Hypothesis 2)
9.1.3 Correspondence between knowledge and practice (Hypothesis 3)
9.1.4 Effectiveness of intervention in a real life context compared to a simulation context (Hypothesis 4)
9.1.5 Similarities and differences between professions
9.1.6 Critique of research methods
9.1.7 Implications for education
9.1.8 Implications for practice
9.1.9 Implications for research
9.1.10 Chapter summary

9.1.1 Effectiveness of conventional teaching (Hypothesis one)

The first aim of this study was to determine nurses' and physiotherapists' knowledge and practice of tracheal suctioning after conventional teaching. The purpose of the initial teaching was to create a level field, so that all participants would commence the study having received the same amount of educational input. It was hypothesised that participants would demonstrate a higher level of knowledge after conventional teaching. As anticipated, the results of the study generally support this hypothesis, as in both the clinical and simulation setting improvements were seen in the participants' knowledge scores. However, for most elements of suctioning improvements were slight.

Knowledge prior to initial teaching was extremely poor in some areas. This was true for participants in both the simulation and clinical settings. Particular areas of knowledge deficit related to awareness of normal saline recommendations, with few participants in either the simulation (n = 17, 18%) or clinical (n = 14, 25%) setting aware that saline should not be used. Furthermore, these proportions did not change significantly after teaching. This is against all research recommendations, as saline has been shown to cause hypoxaemia (Ackerman 1990; Ackerman and Mick 1998; Akgul and Akyolcu 2002), dyspnoea (O'Neil 2001) and infection (Hagler and Traver 1994), with no evidence to indicate that it increases sputum removal (Kinlock and Rock 1999; Blackwood 1999). Blackwood (1999) argued that even after 25 years of empirical work in this field, inconsistencies remain and individuals cite anecdotal evidence of its effectiveness. In their questionnaire survey of nurses and respiratory therapists, Schwenker et al (1998) demonstrated how one third of their sample (n = 62, 33%) reported to frequently use saline whilst suctioning. These findings also support work by Sole et al. (2002) where many staff had reported that they almost always instilled normal saline when suctioning, and are consistent with findings in the ICU setting.

It was encouraging to observe that few participants (n = 5, 5%) in either setting actually used saline in practice. This might have been because participants were using their clinical judgement and believed there was no need to use saline on that occasion. This could also account for the limited use of saline in the simulation setting, as there would be no need to use saline with a mannequin. However, it is also possible that participants made conscious decisions not to use saline as a result of teaching, with the knowledge that they were being observed and judgements made about their practice.

Other knowledge deficits related to the reporting of excessively high suction pressures, as few participants in either the simulation (n = 8, 21%) or clinical (n = 17, 30%) setting were aware of research recommendations, although knowledge did improve after teaching. This finding was also reflected in practice, as few participants in either the clinical (n = 9, 16%) or simulation setting (n = 11, 28%) suctioned using the recommended pressures. Excessively high suction pressures have been associated with trauma, mucosal damage (Czarnik et al 1991) and hypoxaemia. This was, however, unlikely to have occurred in practice as extremes of pressure were avoided and deteriorating oxygen saturation levels were not observed.

Knowledge of infection control practices post suctioning were also poor, with very few participants in either the clinical (n = 9, 16%) or simulation (n = 1, 3%) setting mentioning hand washing in their questionnaire responses. In the simulation setting, this was also reflected in practice, as few (n = 3, 8%) washed their hands. However, in the clinical setting many more (n = 38, 68%) were observed washing their hands after suctioning. For knowledge, this could have been due to the way in which the questions were phrased, as these were purposefully open in an attempt to avoid leading the respondent to an obvious answer. In reality, practitioners might indeed wash their hands after an invasive procedure, even if gloves are worn. However, in an artificial environment such as the simulation setting, practitioners might forget to wash their hands if they are not prompted to do so by the patient or the need to go about their every day duties after the procedure.

On the whole, these baseline findings are consistent with earlier work in both the ICU and acute ward settings (Day et al. 2001; 2002b). It is well documented in the literature that one off conventional teaching sessions led to short term improvements in knowledge and do little to enhance the relationship between knowledge and skills (Chamberlain et al. 2002; Greig et al. 1996; Handley 2002). The findings have shown that, in spite of receiving conventional teaching, gaps in knowledge remained. The findings have also shown, in spite of an increased awareness of research recommendations, practice is not necessarily based on current best evidence. It was anticipated at the outset that there might be knowledge and skills deficits at baseline level. These factors were the foundation upon which to base the performance feedback framework to improve knowledge and practice. No previous studies have used this framework for improving tracheal suctioning practices.

9.1.2 Effectiveness of experimental intervention (Hypothesis two)

The second and main aim of the study was to investigate the effectiveness of individual performance feedback on knowledge and practice, and the retention of these skills over time. It was hypothesised that the participants who received performance feedback would sustain a higher level of knowledge and practice when compared to those who received no feedback. This was the theoretical framework that underpinned this study, and was based on work by Bero et al (1998) and Ryan and Lauver (2002). The framework was implemented as a way of testing whether any differences existed between conventional teaching strategies and additional education in the form of feedback. Studies on hand washing (reviewed in Chapter two) demonstrated that multiple interventions including tailored feedback were more likely to have a positive impact on performance over time (Conly et al. 1989; Berg et al. 1995; Dorsey et al. 1996; Larson et al. 1997; Pittet et al. 2000).

Knowledge

The results of this study support the second hypothesis. In the simulation setting, the performance feedback group's post intervention knowledge scores were significantly better than their post teaching scores ($p = 0.041$). The control group, in contrast, showed a slight deterioration, although this was not statistically significant ($p = 0.486$). Overall, the performance feedback group's post intervention knowledge scores were significantly better than the control group ($p = 0.029$).

A similar picture emerged from the clinical setting, where the performance feedback group's knowledge scores were also better than their post teaching scores ($p = 0.014$). The control group's knowledge scores also improved very slightly but this was not statistically significant ($p = 0.948$). Overall, in the clinical setting, there were no significant differences between the performance feedback and control groups scores post intervention ($p = 0.187$). However, when the two data sets were subsequently merged, statistically significant improvements were seen in the performance feedback group's knowledge scores overall ($p = 0.004$).

Specific areas of improvement related to knowledge of hyperoxygenation as a recommendation, hand washing and providing reassurance to the patient. However, for most individual elements, improvements were slight and did not reach statistical significance.

In the clinical setting, the improvement in the control group's knowledge score post-intervention was an unexpected finding. This could have been a result of participants revisiting the "best practice recommendations" or the literature about suctioning prior to being observed and completing the questionnaire for the final time. This is a well documented limitation of an experimental design (Polit and Hungler 1995) and can threaten internal validity (Campbell and Stanley 1966). Contamination was unlikely since this group received no performance feedback and would not have been aware of their own previous knowledge or practice scores, or of any areas for improvement. However, in spite of these issues, improvements were slight and could perhaps simply have been a result of having completed the questionnaire before.

When comparing results from the merged data, there were no statistically significant interactions between the groups and settings, the groups and professions, or the professions and the settings. This demonstrated that there was no difference in the effect of the intervention on the groups, settings or professions. Overall improvements in knowledge were likely to have been a result of individualised performance feedback, and would therefore appear to support this intervention.

None of the studies reviewed pertaining to performance feedback had investigated the effect on knowledge, as all focused on practice as a representation of "performance". It is not therefore possible to make comparisons. This is the first study to examine the effect of feedback on knowledge *in addition to* skills retention, and to critically analyse the relationship between these two dimensions of performance.

Practice

The results of this study also support the second hypothesis for practice. In the simulation setting, the performance feedback groups' post intervention practice scores were significantly better than their post teaching scores ($p = 0.001$). The control groups' practice scores, in contrast, were significantly worse than their post teaching scores ($p = 0.010$). Overall, the performance feedback groups' post intervention practice scores were significantly better than the control group ($p = 0.029$).

A similar picture emerged from the clinical setting for practice. The performance feedback groups practice scores increased substantially after the experimental intervention ($p = 0.001$). The control group's cores also improved slightly, although these were not significantly different to their post teaching scores ($p = 0.183$). Overall, the performance feedback group had significantly higher practice scores than the control group ($U = 187.000$, $p = 0.037$).

Specific areas of improvement related to hyperoxygenation, with more participants from both the clinical (n = 3, 17%) and simulation (n = 10, 59%) setting hyperoxygenating in practice. Participants were also observed suctioning using the recommended pressures and time frames, and statistically significant improvements were seen for hand washing post suctioning.

Interestingly, there were much greater improvements for practice than knowledge, and it could be argued that this study has demonstrated that the performance feedback framework had a more powerful effect on practice. It is indeed highly probable that having received feedback participants would want to make sure that they practiced correctly next time. Furthermore, although the feedback focused on knowledge as well as practice, it could be argued that the participant placed more of a focus on practice, perhaps believing that it is more important. These issues could be more closely examined through future research.

For practice, statistically significant interactions were seen between the groups and settings ($p < 0.001$). This demonstrated that the effect of the intervention differed across settings, as in the clinical setting the control group's practice scores were higher that those of the simulation setting. Improving practice and ensuring that it is based on the best available evidence was one of the main aims of this study. Having the opportunity to practice these skills and refine suctioning techniques was considered fundamental in an attempt to close the practice-competence gap identified by Scholes and Endacott (2003). It has been clearly documented in the literature that we remember only 10% of what we hear, 25% of what we see, but up to 90% of what we do (Ginman 2005; Scholes 2006). This illustrates the importance of practice.

Having established that the intervention was effective overall, it is also important to consider the mechanisms in which the performance feedback framework improved knowledge and practice. Bero et al (1998) identified specific interventions that were more likely to promote behavioural change, which included audit and performance feedback, educational outreach visits and reminders. Wensing and Grol (1994) recommended that reminders should be visual as well as verbal. Several authors have also suggested that personalised feedback can serve as a reminder (Van de Mortel and Heymann 1995; Tibbals et al. 1996; Khatib et al. 1999). Within the context of this study, performance feedback was classed as a reminder (both visual and verbal) and was delivered with this intention. It is therefore possible that the improvements seen were a result of being reminded about current research recommendations. It is further speculated that having received feedback the participants were motivated to improve, for the sake of their patients or, perhaps, by embarrassment at having their actual scores pointed out, with areas for improvement identified. There could also have been an element of competition within the sample, with participants wanting to perform better than their colleagues.

O'Brien et al. (1997), however, believe that audit and feedback on performance is different to a reminder. Their definition of feedback was a summary of clinical performance over a period of time, yet they don't define a reminder. In their systematic review, they concluded that reminders might be more effective than audit and feedback, and go on to say that few studies have investigated the effect of varying characteristics of the feedback process. O'Brien at al (1997) recommended that consideration should be given to important characteristics of the feedback process such as content, timing, format and delivery. In relation to tracheal suctioning feedback, these issues were all taken into account at the planning stage when the intervention was initially developed. However, the feedback was standardised, which was fundamental to the research design.

The timing of the feedback was also an essential consideration, which O'Brien et al. (1997) had identified as being missing from many studies. Axt-Adam et al. (1993) suggested that timing of feedback is crucial when attempting to change performance. In this study, performance feedback was given between seven and ten weeks after conventional teaching, and there was a four-week window for delivering this intervention. Participants were then observed suctioning over the next six weeks and completed the final knowledge based questionnaire. It was acknowledged at the outset that those who were observed shortly after feedback (i.e. those who received later feedback and an early observation) might perform better than those observed later, as they might remember more. For these very reasons, the feedback was written as well as verbal. However, in the event this is not thought to have occurred, as knowledge and practice improved regardless. In view of these issues of timing and process, it would now be useful to examine the mechanisms in which performance feedback improves knowledge and practice by varying elements of the feedback process, as recommended by O'Brien et al. (1997). This is an area for future research.

9.1.3 The correspondence between knowledge and practice (Hypothesis three)

The study also aimed to examine the relationship between knowledge and practice. It was hypothesised that the participants who received individual performance feedback would demonstrate a closer correspondence between knowledge and practice compared to those who did not receive feedback. As anticipated, there was a weak correspondence between knowledge and practice in both settings at baseline level. These findings were consistent with earlier work. However, following the experimental intervention, the correspondence between knowledge and practice deteriorated in the performance feedback group. This was an unexpected finding.

A number of studies have demonstrated discrepancies between theory and practice (Day 1995; Gould et al. 1996). In both studies, knowledge was better than practice, a finding that was mirrored in the two previous studies. Indeed, the rationale for using observation as a research method in this study was because different results could have emerged with participants reporting a level of knowledge that was not reflected in actual practice. However, unlike previous studies, practice was better than knowledge, which was an unusual finding and in complete contrast to earlier work.

The theory-practice gap is a recurring theme in the literature (Cook 1991; Jordan 1994; Rolfe 1998). There are a number of ways to explain incongruence between knowledge and practice. Norman et al. (1992) argued that the use of multiple research methods might explain discrepancies between knowledge and practice. According to Norman et al. (1992), method triangulation, for the purpose of completeness, involves the use of more than one research strategy in order to reveal the various dimensions of the domain of interest. However, as Norman et al. (1992) acknowledged, the researcher who uses method triangulation cannot always expect multiple sources of data to confirm each other, since they reflect different dimensions. This argument may partially account for such a discrepancy, as it could be argued that although practice is one way of enacting knowledge, they are nevertheless different dimensions. It is, however, interesting to see how the direction of the findings differ to the previous studies in ICU and acute ward settings, where practice was worse than knowledge.

Larsen et al. (2002) believe that there is no gap between theory and practice. Using the sociological theory of Bourdieu, which challenged the "barrier paradigm" that has traditionally highlighted the gap between knowledge and practice, Larsen et al. (2002) set out to investigate what knowledge nursing theorists and practitioners actually use. Through interviews, they identified that the knowledge used in clinical practice came primarily from other colleagues and the context of care as opposed to theory and conferences. The authors concluded that theory and practice exist in their own right as two different types of knowledge; theoretical knowledge and practical knowledge. This support's Norman's argument, and the notion of knowledge and practice as different dimensions of performance. Larsen et al. (2002) also acknowledged that knowledge and practice are not hierarchically ordered, as each should exist in their own right and be seen as a continuum.

Controversy around these different dimensions of knowledge could also account for some of the difficulties associated with defining and operationalising what is meant by the term "competence". Some educationalists have described it as the successful integration of theory and practice (Milligan 1998; Scholes et al 1999) but, as this study has highlighted, perhaps it is not that simple. Most competency frameworks incorporate elements of theoretical knowledge, practical knowledge (skills) and attitudes to reflect overall performance, thus attempting to capture all dimensions.

Cognitive dissonance theories have been implicated in theory and practice discrepancy (Niven 1989; Abraham and Shanley 1992) and attempt to determine the relationship between attitudes and behaviour. However, this study did not focus on attitudes, and a more plausible explanation is simply that the performance feedback had a more powerful effect on practice. It is indeed possible that the participants believed that aspects of performance were more important than their questionnaire responses, and prioritised this during the final set of observations. It is also possible that the person giving performance feedback inadvertently placed more emphasis on practice, although this was unlikely as the findings were the same for both settings.

The conditions under which the final questionnaires were completed could also have had an impact on knowledge, as this took place in the workplace, and participants would have had other things on their minds. However, as the same questionnaire had been completed twice before, it would not be unreasonable to expect to see improvements. If, as Norman et al (1992) suggested, by using triangulation one cannot expect different methods to confirm each other, perhaps it is not appropriate to consider or even test the relationship between knowledge and practice as a predictor of accurateness. This would also support Larsen et al. (2002) argument, that theoretical knowledge and practical knowledge are two different types of knowledge. Although Larson et al. (2002) would probably not agree, it could be argued that the most important aspect of this study *was* to improve practice, and practice is a reflection of knowledge. It is therefore perhaps not surprising that by improving practice the relationship between these two variables is weakened.

Another important point to consider here is that although most participants' knowledge improved, there were some aspects that did not, but they still practiced correctly. This could, of course, have occurred by chance. However, it is also possible that for some aspects of suctioning they could have been learning by rote without really understanding the rationale behind their actions. This is a cause of concern and could influence future practice. Follow up interviews, exploring the rationale for actions and evaluating knowledge and practice over time would enable these issues to be more closely examined. This is an area for future research.

9.1.4 Effectiveness of intervention in a real life context compared to a simulation context (Hypothesis 4)

The study also aimed to determine whether providing performance feedback in a simulation setting has the same effect as feedback in a clinical setting. It was hypothesised that there would be no difference in knowledge and skills between participants who were observed using simulation compared to those observed in practice. On the whole, the results support this hypothesis as findings were similar in both settings for knowledge and practice, although the effect was greater in the simulation setting.

It was encouraging to note the similarities between the two settings, which demonstrated that simulation was an appropriate a method of evaluating performance. This correlates well with previous work (Alinier et al. 2004; Gates et al. 2002; Gomez and Gomez (1987). A number of other educational programmes, including Intermediate and Advanced Life Support and courses such as the Acute Life Threatening Events Recognition and Treatment (ALERT™) and Care of the Acutely Ill Surgical Patient (CCrISP™) are delivered and assessed using this format for doctors and other healthcare professionals (Smith et al 2002; Smith and Poplett 2004; While and Garrioch 2002).

Gates et al. (2002) argued that it is also important to consider the role of simulation as an evaluation strategy for research. This method was selected as it provided a unique opportunity for the participants to be observed in a simulation setting using a mannequin specifically designed for evaluating these skills. Indeed, simulation with mannequins not only enables evaluation of skill retention, but also provides the opportunity for feedback on performance with suggestions for improvement, which formed the basis of the theoretical framework that underpinned this study.

Roberts et al. (1992) questioned the most appropriate location for the simulation and whether this should be in a clinical or laboratory style setting. The empirical evidence in this field is limited. In their study of recording blood pressure, Gomez and Gomez (1987) found that student nurses taught in practice performed better in terms of both accuracy and level of confidence. In relation to this study, a decision was made to observe all participants in a practice setting, and the simulation was set up in an empty bed space on the participants' own ward. This was felt to be an important aspect of simulating the "real life" context, and had an artificial environment been used it would have been very difficult to organise essential equipment such as suction and piped oxygen. The findings of this study appear to support those of Gomez and Gomez (1987), suggesting that simulations should ideally take place in the clinical setting. However, there are potential limitations. For example, the availability of empty beds on a busy ward can never be guaranteed. Indeed, on some occasions an empty bed area was not readily available and the simulation was delayed. The proximity of other patients and staff could also influence the simulation.

There are two main types of presenting information within a simulation; the response based and the process based method (Rimoldi 1988). This study used the response based method, whereby the participant was given details of an actual patient case study. This method standardised the information given to all participants, which Jones (1989) argued is appropriate for a structured evaluation of a clinical skill. Although this method has been criticised for not promoting critical thinking and decision making (Jones 1989; Cioffi 2001), the method of assessment was standardised which was fundamental to the RCT research design.

Issues of ecological validity are also fundamentally important in any study using an experimental design. Whilst there are similarities between external and ecological validity, there are nevertheless key differences. In order for a study to possess ecological validity, its' research methods, materials and settings must be appropriate to the "real life" context. Cioffi (2001) argued that when using simulation, essential information must be presented in a way that mimics reality. A number of patient scenarios were developed, based on "real life" patient case studies (anonymity preserved). Each participant was given a scenario related to their own specialist area. For example, nurses working in acute medical wards were given scenarios related to patients with medical conditions, thus attempting to create the "real life" context. It is likely that these patient scenarios contributed to the success of the simulation, as the participants were not thrown by an unfamiliar area of practice, which could have influenced the results. Few other studies using simulation appear to have reported such details.

The strength of the simulation is further supported by the rigorous inter rater reliability testing of the observation schedule. This took place at the start and mid point of data collection. Percent agreements and kappa values were almost identical to those of the clinical setting. The schedule was found to test the same elements in both settings on a consistent basis, demonstrating validity and reliability of the instrument. All of these issues contribute to the ecological validity of the study, the methods, instruments and indeed the two settings used.

One important point to acknowledge is that this study took place on two separate sites, with participants observed on one site in a clinical setting and the other in a simulation setting. Factors other than the simulation could therefore have affected the participant's performance on that particular site. This limits the ability to generalise findings and it can only be speculated that this is an area worthy of exploring as an innovative research method in clinical practice. In view of these issues, it will be important to compare the effect of performance feedback on *actual* practice when participants had received feedback on *simulated* practice. This is an area for future research.

9.1.5 Similarities and differences between professions

Potential similarities and differences between the professions were not one of the original hypotheses. However, it is important to highlight and analyse any inherent differences that have become apparent. It was acknowledged at the outset that the context in which patients were suctioned might differ between professions, but that participants should still practice according to current research recommendations.

As health and social care continues to become more complex, effective collaboration between healthcare professionals is essential. However, there is increasing evidence to suggest that such collaboration does not always occur in practice (Zwarenstein et al. 2000). Furthermore, it is widely acknowledged that practice lags behind the available empirical evidence, and that this is a common issue in nursing, medicine and other allied health professions (Haines and Donald 1998; LeMay et al. 1998; Closs and Cheater 1999; McClaren and Ross 2000).

Zwarenstein et al. (2000) suggested that interprofessional education (IPE) offers a possible way forward. The underlying principles of IPE are for different professional groups to meet, interact with each other and learn together in a collaborative manner. This is believed to have a positive impact on interprofessional working and ultimately the health and well-being of patients. Indeed, in many other countries, IPE has long been identified as a means of enhancing collaborative practice between professions in the health and social care sectors, which has been shown to improve care (WHO 1978; WHO 1988).

Zwarenstein et al. (2000) examined systematic reviews to assess the usefulness of IPE interventions compared to education delivered within professional groups. However, despite a large amount of available literature evaluating IPE, many studies lacked the methodological rigour needed to be able to effectively analyse the impact of IPE on professional practice and patient outcomes. Nevertheless, despite this disappointing lack of evidence, Zwarenstein et al. (2000) argued that there is no reason to suggest that IPE is ineffective and that further, more rigorous, research needs to be undertaken in this field.

This study originally intended to incorporate some components of IPE, with nurses, physiotherapists and doctors (anaesthetists) taught and observed together in a collaborative manner. However, in the event, anaesthetists were not able to take part in this study as they do not perform tracheal suctioning very often. As the study eventually involved only two professional groups, was unable to fully assess patient outcomes or the impact on care, the IPE framework was therefore not considered appropriate. However, in spite of this, most of the initial teaching sessions did involve a mixture of nurses and physiotherapists. This was primarily to promote communication between the two disciplines, and to discuss any issues that have historically been considered controversial, such as the use of saline.

A number of studies exploring nurses and therapist's knowledge of suctioning have shown discrepancies between the two professions (Brooks et al. 1999; Schwencker et al., 1998). Schwenker et al. (1998) examined nurses and respiratory therapists practice regarding the use of saline and suctioning. Their findings showed a tendency for more therapists (n = 35, 71%) than nurses (n = 26, 19%) to report that they regularly used saline. The findings of this study support those of Schwenker et al. (1998). Highly significant differences were seen in this study between the professions for knowledge of normal saline recommendations before ($p < 0.001$) and after teaching ($p < 0.001$). On both occasions, all except one physiotherapist (n = 31, 97%) reported that saline would be used, compared to only one third of nurses (n = 20, 36%). Furthermore, these figures did not change after performance feedback, with only one further physiotherapist reporting that saline should not be used. These differences remained highly significant ($p < 0.001$). This suggests that, in spite of classroom based discussions, and subsequent performance feedback for the intervention group, there had been no notable change in knowledge. This supports previous work.

This finding was reflected in practice with more physiotherapists using saline. After teaching, four physiotherapists compared to one nurse were observed instilling saline. This difference was statistically significant ($p = 0.043$). However, after performance feedback, three physiotherapists compared to two nurses used saline in practice ($p = 0.228$).

After performance feedback, differences were also found between the professions for hyperoxygenation, with more physiotherapists (n = 21, 70%) than nurses (n = 24, 43%) preoxygenating before suctioning. This could have been due to the physiotherapists having an increased awareness of recommendations at baseline level, as all (n = 32, 100%) stated that they would hyperoxygenate in their questionnaire response, although not all (n = 14, 43%) hyperoxygenated in practice. Less than half of nurses (n = 26, 41%) preoxygenated in practice at baseline level, although many (n = 49, 78%) were aware of recommendations. For nurses, this lack of adherence to research recommendations could suggest that hyperoxygenation is an area that they were unfamiliar with and therefore concerned about changing their practice. It is also possible that as oxygen is considered a drug, and should therefore be prescribed, nurses might believe that acting outside of such parameters poses a threat to their NMC Code of Conduct (NMC 2002). Hyperoxygenation prior to suctioning is recommended as a strategy to minimise the risk of complications such as hypoxaemia and cardiac rhythm disturbances (Adlkofer and Powaser 1978; Stone at al. 1991b; Wood et al. 1998a).

The findings are interesting and have demonstrated that for some aspects of practice, such as hyperoxygenation, physiotherapists are more likely to practice according to research recommendations. This could reflect an increased level of autonomy and the tendency for physiotherapists to act within their own scope of practice according to acknowledged professional boundaries. However, it is also interesting to note that for other aspects of practice, such as the use of saline, physiotherapists are more likely to act outside of research recommendations. These findings support those of Sole et al. (2002) who also demonstrated that respiratory therapists were more likely to use hyperoxygenation and normal saline instillation than nurses. According to Sole et al. (2002), most of the institutions in their survey reported that normal saline instillation was documented in their policy for clearing thick secretions, with many staff stating that they almost always instil normal saline when suctioning.

Field notes taken during the conventional teaching sessions highlighted the discussion and controversy surrounding the use of saline, as physiotherapists from both settings anecdotally reported that saline actually works and can help to loosen secretions. This is against all research recommendations and supports Blackwood's (1999) argument that despite a plethora of work in this area, individuals still cite anecdotal evidence of its effectiveness.

Problems with implementing research findings into practice have long been documented (Felch et al. 1997; Muir Gray 1997; Nolan 1998). French (1999) argued that even in the late 1990's many practices are based on experience, ritual, intuition and common sense and, despite an increasing body of knowledge about the effectiveness of interventions, there remains a discrepancy between theoretical knowledge and practical application. This argument certainly seems to apply to saline and suctioning, and this is consistent with earlier findings in both the ICU and ward setting. Hunt (1996) put forward a number of reasons for this lack of implementation of research findings. These include a lack of knowledge and understanding, plus a lack of awareness of how to use research. Hunt (1996) also argued that practitioners might not believe the research findings. This study has been successful in changing many areas of practice but, for physiotherapists, the use of saline is not one of them. It is therefore proposed that physiotherapists *do not believe* the empirical evidence surrounding saline and reserve the right to make their own clinical decisions, based on experience and intuition. However, if this also includes, as French (1999) argued, ritual and tradition, this is a cause of concern about an aspect of practice that could be taken for granted.

It is also important to acknowledge that some clinical skills, once acquired, are rarely forgotten, and can be carried out without a great deal of thought. They can be compared to "riding a bike". In critical care, examples where this concept could apply includes the interpretation of arterial blood gases and electrocardiography (ECG). It is therefore possible that if physiotherapists are used to using saline on a regular basis, as indicated in their questionnaire responses, it might be difficult for this skill to be "unlearnt". This was also apparent in research in the ICU setting, where a number of participants had used a rotational technique to suction. Even after teaching, they had been unable to withdraw using no lateral movement as although they were aware of current recommendations they were used to using the rotational method.

The issue of unlearning in health care has become a recent theme in the literature. Rushmer and Davies (2004) argued that whilst a great deal is known about the nature of learning, very little is known about the process of unlearning. They argued that it can be naïve to believe that unlearning will automatically occur when factors which sustained the original learning are removed, suggesting that past learning will fade over time. They point out the difference between routine unlearning, which is subsequently replaced by re-learning, and deep unlearning, which requires a major break from all previous modes of understanding. Within this context, they argued that:

"deep unlearning is a sudden, powerfully painful, confrontation of the inadequacy in our substantial view of the world and our capacity to cope with that world competently" (Rushmer and Davies 2004, p. ii10).

It has been widely acknowledged that individuals and organisations might find the process of unlearning challenging with numerous reasons given for resistance to change (Spinney 2000; Rudman 2001). However, it is without doubt that if practice is to become evidence based, a certain amount of unlearning needs to take place. For some aspects of practice, such as the use of protective eye wear during suctioning, nurses and physiotherapists were able to successfully demonstrate re-learning, as after performance feedback goggles were consistently worn on the majority of occasions. This could be seen as routine unlearning and change was successfully implemented. However, for other aspects of suctioning this was more problematic. As the literature has highlighted, for physiotherapists, the instillation of saline prior to suctioning has historically been a traditional dimension of their practice. The process of unlearning this skill is therefore likely to take time, and it is suggested that this will require a more powerful intervention than performance feedback to change knowledge, beliefs and attitudes. It is also recommended that a member of their own profession should be involved with the process of changing these aspects of tracheal suctioning, as it will require deep unlearning which could prove challenging and painful.

On the whole, it is important to acknowledge that despite these individual item differences, overall results demonstrated no statistically significant differences between the professions in either setting for knowledge. There were, however, statistically significant differences between professions for practice, with physiotherapists performing better than nurses overall, an effect which did not vary across settings. This could have been due to physiotherapists suctioning more often than nurses, as their practice spans different wards and departments and they are likely to treat more patients. Physiotherapists are also more likely to follow the patient through their hospital journey, perhaps treating them in the ICU and following up on the HDU or ward. Nurses, on the other hand, will only care for the patient in their specific ward and their practice is dependent upon the number of patients admitted with tracheotomies. These factors could account for the differences seen in practice as physiotherapists have more of an opportunity to refine and perfect their skills.

9.1.6 Critique of research methods

From this study, a great deal of information was obtained about individualised performance feedback and its impact on tracheal suctioning practices in both a clinical and simulation setting. Key differences between nursing and physiotherapy practices have also been identified. A detailed rationale for the study developed from an in-depth review of the literature and two previous studies that were undertaken as part of this ongoing programme of research, hence previous work informed the design. Furthermore, various assumptions underpinning an experimental design, using an RCT approach, have been met (Oldham 1994; Stewart and Parmar 1996). Indeed, one of the major strengths of this study relates to the design, and a strict adherence to a systematic and rigorous research protocol.

9.1.6.1 Conventional teaching programme

The conventional teaching programme took place over a one-hour period in a ward-based environment. This standardised programme is considered a strength of the study, as it was based on the best available research evidence. In addition, for consistency, all sessions were delivered by either the principal investigator or research assistant. However, for pragmatic reasons, these sessions were confined to a one-hour period. On reflection, this was somewhat rushed and it might have been preferable to have had more time, especially to allow for the first knowledge-based questionnaire to be completed. In reality, however, it is unrealistic to think that more time would have been available.

9.1.6.2 Individual performance feedback

The experimental intervention consisted of performance feedback, which was tailored to the individual and consisted of knowledge before and after teaching, performance in practice, including the participants' actual scores. This approach was also considered a strength of the study, and the researcher who collected data on that site was blind to the feedback process. However, one limitation of the feedback is that participants quickly became very focused on their actual scores. Instead of being concerned with how to perform better next time, both in terms of their questionnaire responses and also in practice, they wanted to know how they could improve their scores. With hindsight, it might have been better not to include actual scores with the feedback. This argument may also account for greater improvements in practice with participants prioritising this as more important in order to achieve a higher score. Nevertheless, in spite of these issues, the performance feedback still proved to be a valuable framework for improving practice in both settings.

9.1.6.3 Research instruments

An additional strength of the study is that two research methods were employed. Both data collection instruments were designed together so that comparisons could be made between knowledge and practice. The instruments were validated by an expert panel and were subsequently validated through previous research.

In relation to the knowledge based questionnaire, one issue that could have posed a threat to internal validity was the pre-test and post-test design. The participants in the performance feedback group were expected to improve their knowledge scores thereafter. However, it might have been difficult to evaluate whether this was due to the experimental intervention or, indeed, as Coolican (1994) argued, because they had completed the test before. This possibility was greatly reduced by the RCT research design and the use of a control group. Overall, the performance feedback groups' knowledge scores did improve, whereas the control groups' did not, which suggests that the repeated use of the knowledge based questionnaire did not have a major effect.

Another limitation relates to the observations and potential observer fatigue. This was considered unlikely, as tracheal suctioning is a relatively quick procedure, although it was often necessary for the researchers to remain in the practice environment for some considerable time until it was appropriate for the procedure to take place. However, participant fatigue could have influenced performance, as it was sometimes necessary for the observations to take place at the end of a long day or night shift. For consistency, it would have been preferable to have carried out the observations at the start of each participant's shift.

Another key area affecting the validity and reliability of the research instruments lay in their construction and method of scoring. Although the tools were piloted more than once, were used in two previous studies and were considered to be valid in relation to content, a more rigorous analysis of the items and scores could be undertaken, as it is possible that some of the items might have contributed to the overall scores more than others. A rotational factor analysis of responses would now provide this information (Robson 1993; Polit and Hungler 1995), as it constitutes a means of exploring the convergent and discriminant validity of a large set of measures. This work should be undertaken if the instruments are to be used in future research.

9.1.6.4 Research design

In any single blinded RCT research design, there is the potential for contamination of research findings in relation to the interventions and the participant's responses. Considerable effort was made to minimise these risks by collecting data over a relatively short period of time, not disclosing names of participants in either group or indicating who had received performance feedback. The best practice recommendations were also watermarked with "do not copy" to avoid distributing the documents to others before they received the conventional teaching programme. However, in spite of this, it is possible that some interaction did occur in one of the settings, as demonstrated by an improvement in the control groups practice scores post intervention. However, the potential adverse effects of contamination were considered minimal, as the performance feedback had been tailored to the individual.

The "Hawthorne" effect is another well-documented limitation of observational research and can threaten external validity (Polit and Hungler 1995). Attempts had been made to minimise these risks by remaining detached from the bedside and not disclosing detailed components of each observation. In the two earlier studies, the observations took place before the completion of any knowledge based questionnaires, which was important so that participants would not be aware of the specific aspects of practice observed in an attempt to minimise the "Hawthorne" effect. However, in this study, detailed components of the suctioning procedure were revealed through performance feedback. In the clinical setting, the control groups' practice scores were higher than those of the simulation setting, which could possibly be attributed to the "Hawthorne" effect.

In experimental research, there is the possibility of making a Type I or Type II error. The risk of a Type I error was reduced by accepting a 5% level of confidence or $p < 0.05$. Type II errors are reduced by calculating a sample size according to a power of at least 0.8 (Lipsey 1990; Ingram 1998). An initial power analysis calculation based on previous data showed that a sample size of 10 per group could be powerful enough to detect a difference. This very small sample estimation did not appear sufficient, and a decision was made to increase this figure to reflect the maximum participants available to take part in the study, estimated at approximately fifty per group. In the event, there were 95 participants in total and an adequate statistical power was demonstrated.

9.1.7 Implications for education

A number of implications for education have emerged from this study. Following detailed feedback on their performance, significant improvements were seen in the participant's knowledge. This was also reflected in practice. These effects were consistent across the two settings and demonstrate that the experimental intervention was effective. The success of this study could therefore be attributed to the personalised feedback and individual attention paid to the participants. This highlights the importance of providing detailed follow-up to ensure that practical skills improve and are sustained. Furthermore, the feedback needs to be specific rather than generalised, and should be based on objective criteria. As the literature has illustrated, without detailed follow-up knowledge and skills retention are likely to deteriorate over time.

A number of studies have highlighted that practitioners now appreciate the importance of research (McSherry 1997; Dunn et al. 1998). However, many are reluctant to base their care on empirical evidence (Closs and Cheater 1994; 1999). If practice is to truly become evidence based, clinical skills teaching should either take place within the practice setting or a clinical skills laboratory, as bridging the gap between theory and practice can only be achieved by applying the concepts to practice.

The findings of this study support previous research (Conly et al. 1989; Berg et al. 1995; Dorsey et al. 1996; Larson et al. 1997; Pittet et al. 2000), highlighting performance feedback as a powerful mechanism for improving tracheal suctioning practices. This has huge implications for practice-based education, and it is recommended that this framework be implemented for teaching other complex clinical skills. No doubt this will have obvious cost implications for the NHS, as providing feedback can be time consuming. However, there might be key personnel already in place who would be in a suitable position to give such feedback.

The Lecturer-Practitioner, Practice Educator or Practice Development Facilitator are all examples of staff whose role could include evaluating practice and providing feedback. In the critical care arena, many are already involved with auditing practice through the use of care bundles. The Nurse Lecturer could also be involved. Clifford (1999) believes that nurse lecturers are in a unique position to support practice-based education at the interface between theory and practice. Most higher education institutes (HEI's) require the Nurse Lecturer to spend a minimum of one day per week in practice, although how this time is spent is often open to interpretation. Clifford (1999) argued that different HEI's have different roles for the lecturer in practice, and suggested that the time spent might not be used to optimum advantage. Using the framework of evaluating practice through feedback and research, the Nurse Lecturer would be in an ideal position to engage with the process, which would have the added benefit of ensuring that the lecturer remains up to date with clinical practice as opposed to becoming de-skilled. It is, however, acknowledged that some practitioners might find the process of receiving feedback threatening, especially from a lecturer, and the person providing this information will need to be sensitive and mindful of these issues.

9.1.8 Implications for practice

The multi-method approach has enabled the relationship between knowledge and practice to be closely examined. This is a major strength of the study. Few other studies have looked at these two dimensions of performance, many focusing on either knowledge or practice. The findings of this study have raised some concern about all aspects of tracheal suctioning. At the initial baseline knowledge assessment, some participants were unable to provide accurate answers that were based on empirical evidence. This was also reflected in practice, as many participants performed the suctioning procedure against research recommendations. The main concerns were similar to previous research; inadequate patient preparation, limited use of hyperoxygenation, the use of larger than recommended suction catheters and high negative pressures, all of which are potentially detrimental to the patient. Hand decontamination techniques and limited adherence to universal precautions were also areas of concern, and post suctioning actions such as chest auscultation rarely took place. However, it was encouraging to note that in both the clinical and simulation setting, the performance feedback groups' knowledge and practice improved following the experimental intervention.

The findings are interesting and show that the performance feedback framework was effective in promoting evidence-based practice. It is, however, importance to recognise that in many instances formal assessment of clinical competence is often left to knowledge based assessments. This poses a significant problem in clinical practice, as knowledge can be a poor reflection of performance. Moser and Coleman (1992) suggested that knowledge does not necessarily correlate with skilled performance, and argued against the use of cognitive tests as a sole method of evaluating competence. In order to address these issues, the OSCE, in conjunction with simulation, would be a useful educational strategy for supporting learning and could prove to be a valuable framework for evaluating performance to ensure that practitioners are competent in performing a range of complex clinical skills.

Once again, in accordance with other studies, the relationship between knowledge and practice has been challenged (Day 1995; Gould et al. 1996). As anticipated, the correspondence between knowledge and practice at baseline level was weak. However, it was envisaged that by providing feedback on performance the strength between these variables would improve, as practice should be a reflection of knowledge. However, unlike previous research, practice was better than knowledge, which was an unexpected finding and in complete contrast to earlier work. This suggests, once more, that knowledge is a poor predictor of performance, which also has huge implications for practice-based education. All of these issues support the need for providing education in the workplace and giving personalised feedback on performance.

9.1.9 Implications for research

Important information relating to nursing and physiotherapy practice has emerged from this study and several aspects have contributed to its uniqueness. Although it has followed on from a previous programme of research, no other study has explored tracheal suctioning practices of these two professional groups using a multi-method approach, obtaining both observational and questionnaire data. No other study has used the framework of performance feedback as a way of improving tracheal suctioning practices. The study has also compared practice in a simulation setting to a clinical setting. All of these aspects have contributed to its uniqueness.

A number of areas for future research are now identified. It would be useful to examine knowledge and practice over a longer time frame, to investigate whether the effectiveness of the experimental intervention was retained over time and to determine whether detailed performance feedback is required on a regular basis in order to sustain levels of knowledge and practice. Potential attrition would make this a challenging study to undertake, and in view of this, a multi-centre trial would be more appropriate to capture a larger sample size.

As this study took place on two separate sites, it is possible that factors other than the simulation could have had an impact on the participants' performance. Further research, comparing the effect of performance feedback in both a simulation *and* a clinical setting is needed. Although the results of both settings were very similar, there were a few specific areas of practice, such as hand washing, where there were differences between settings. Future research would involve randomising participants and comparing the effect of performance feedback in a clinical setting following feedback in a simulation setting. This work needs to be undertaken before it can be inferred that this is an area worthy of exploring as an innovative research method. In the event that there was no difference, the simulation setting could be used to evaluate future performance, avoiding the need to undertake observational work with a critically ill patient. In an area of practice where seriously ill patients and their families have enough issues to contend with, as well as the ethical issues associated with consent, this would be a useful framework for future practice based education and research.

9.1.10 Chapter summary

The findings have raised some concerns about all aspects of tracheal suctioning. The first aim of the study was to determine nurses and physiotherapist's knowledge and practice of tracheal suctioning before and after a conventional teaching programme. At the initial baseline level, knowledge was generally poor. This was consistent with the findings of two previous studies that were undertaken as part of this programme of research. These findings were also reflected in practice, with suctioning performed against many of the research recommendations. Overall, knowledge and practice at baseline level was not evidence-based. This is a major area of concern, as tracheal suctioning has been associated with many potential risks and complications. Lack of adherence to recommendations, whether due to knowledge deficits or a conscious decision to deviate from guidelines, will pose serious risks to the critically ill patient and have financial consequences for the NHS.

The second and main aim of the study was to investigate the effectiveness of individual performance feedback on knowledge and practice over time. This was the theoretical framework that underpinned the study. Statistically significant improvements were demonstrated for knowledge and practice post performance feedback, with much greater improvements in practice. The experimental intervention was therefore seen to be effective. The third aim was to compare the relationship between knowledge and practice. As much greater improvements in practice were demonstrated, this resulted in a weaker correspondence between knowledge and practice, which was an unexpected finding and in complete contrast to earlier research. This has challenged previous assumptions about the relationship between knowledge and practice. The study also aimed to compare the effectiveness of providing feedback in a simulation setting with a clinical setting. On the whole, findings were similar in both settings, and provide evidence of the effectiveness of the experimental intervention, although it must be acknowledged the study took part on two separate sites, and is recognised that factors other than the simulation could have contributed to the results on that site.

CHAPTER TEN: CONCLUSION AND RECOMMENDATIONS

10.1 Introduction

This thesis has compared the effectiveness of standardised education with an individual performance feedback framework on nurses and physiotherapists' knowledge and practice of tracheal suctioning. The study aimed to determine nurses' and physiotherapist's knowledge and practice of tracheal suctioning before and after a conventional teaching programme, and before and after performance feedback. The study has also compared the relationship between knowledge and practice, and the effectiveness of providing feedback in a simulation setting with a clinical setting. This chapter summarises the overall findings, and presents a number of unanswered questions that have challenged the original assumptions. Recommendations are made for future studies and it is suggested that this framework could be used for many other aspects of practice based education and research.

10.2 General conclusions

The preceding discussion has demonstrated that performance feedback can be a powerful framework for improving aspects of tracheal suctioning, and for promoting the use of research findings. Improvements in knowledge and practice were generally sustained over time and demonstrate that the experimental intervention was effective overall. One remaining concern was that some participants, notably physiotherapists more than nurses, still believed that it was acceptable to use normal saline instillation before suctioning. This is a major cause for concern as it is not in accordance with either the Scope of Professional Practice, or principles of Clinical Governance, which places a duty of responsibility on all health care professionals to ensure that care is satisfactory, consistent and evidence-based (NHSE, 1996a; Wilson 1998). It is argued that, as saline has historically been a traditional dimension of physiotherapy practice, it is difficult for this skill to be "unlearnt" and will require a more powerful intervention than performance feedback.

The discussion has also made it clear that there are a number of unanswered questions, such as *why* there was a discrepancy between knowledge and practice, and *why* this differed from previous research findings. The two former studies concluded that clinical guidelines for suctioning should be in place, and suggested a number of educational strategies for developing practice, recommending that regular teaching would be required if practice is to remain evidence-based. Performance feedback was subsequently put forward as an appropriate educational strategy, and it was hypothesised that this would achieve a closer correspondence between knowledge and practice in an attempt to close the theory-practice gap. However, this study has demonstrated that performance feedback had a much more powerful impact on practice and, once more, has highlighted the discrepancy between knowledge and practice. This has major implications for practice based education and research. What is interesting is the direction of these findings, and how this contrasts with other research where knowledge was better than practice (Day 1995; Gould et al. 1996).

These two dimensions of performance were thought to be related and linear, and that by improving one aspect the other would also improve. If anything, if a theory-practice gap did exist, it was envisaged that theoretical knowledge would be *better than* actual practice. This study has challenged that assumption, which could suggest, as Larsen et al. (2002) argued, that theoretical knowledge and practical knowledge reflect different dimensions of performance. It cannot therefore be presumed that by improving knowledge practice will also improve. Equally, it cannot be presumed that apparent knowledge deficits will also result in poor performance in practice. This supports the argument of Norman et al. (1992) that by using multiple methods, the researcher cannot necessarily expect different sources of data to confirm each other.

This discrepancy between knowledge and practice could also have been related to the data collection instruments and the evaluation methods used. It is speculated that greater improvements in practice could have been a result of participants placing more of an emphasis on practice, believing that this aspect of their performance was more important that their knowledge based questionnaire responses. Further research, investigating the rationale for actions, would enable these issues to be more closely examined.

10.3 Recommendations

This study has obtained important information about nursing and physiotherapy practice, and how practice is informed by knowledge. On the whole, providing the practitioner with detailed feedback proved to be a useful strategy for evaluating these two dimensions of performance, both in the clinical and simulation settings, as both aspects did improve. The findings have highlighted some recommendations for education and research. Previous studies have identified discrepancies between knowledge and practice, and challenges associated with the retention of knowledge and skills. Performance feedback was put forward as a possible solution to these problems, although no previous studies have evaluated this framework in teaching a complex clinical skill such as tracheal suctioning. The main recommendation is for the framework to be incorporated into teaching and researching other complex aspects of clinical practice, both in the critical care arena and elsewhere. In relation to tracheal suctioning, it is recommended that knowledge and practice are regularly evaluated through the tracheostomy care bundle, as suctioning is a key element.

As this study has shown, it is no longer adequate to simply evaluate knowledge as it can be a poor reflection on practice. It is recommended that knowledge and practice are evaluated equally, following performance feedback, and this process will hopefully promote evidence-based practice. It will also be important to ensure that details about any possible discrepancies between knowledge and practice are pointed out to the practitioner so that they are given the opportunity to reflect on potential reasons. The framework could be used for a wide range of practices, possibly in a simulation setting using an OSCE style approach, which could avoid the need to conduct experimental or observational work with the critically ill. However, a degree of caution is recommended as further research should be undertaken to compare the effects of feedback in both settings before this is considered an innovative research strategy. Suggestions for future research are presented in Table 10.1

Table 10.1 Suggestions for future research using the performance feedback framework.

Example	Element of performance	Proposed Setting
1. ECG recording and interpretation	**Knowledge** of electrophysiology and cardiac rhythms **Practice** of taking and interpreting an ECG	Clinical or simulation, using the Heartsim and cardiac monitor
2. Central Venous Pressure (CVP) monitoring	**Knowledge** of CVP monitoring, measurements **Practice** of measuring the CVP	Clinical or simulation, using clinical skills laboratory
3. Enteral feeding in the critically ill	**Knowledge** of nutritional assessment, requirements and feeds **Practice** of nutritional assessment and commencing prescribed feeds	Clinical or simulation, using clinical skills laboratory and scenarios
4. Arterial blood gas sampling	**Knowledge** of arterial lines and how to sample **Practice** taking a blood gas sample	Clinical or simulation, using the clinical skills laboratory
5. Arterial blood gas analysis	**Knowledge** of arterial blood gases **Practice** of interpreting blood gases	Clinical or simulation, using clinical skills laboratory and scenarios
6. Tracheostomy care	**Knowledge** of tracheostomy care **Practice** tracheostomy management	Clinical or simulation Evaluation through tracheostomy care bundle
6. Non invasive ventilation (NIV)	**Knowledge** of NIV **Practice** setting up and managing NIV	Clinical setting Evaluation through ventilator care bundle
7. Breaking bad news to relatives of the critically ill	**Knowledge** of how to break bad news **Practice** associated with actually breaking bad news	Clinical or simulation, using clinical skills laboratory and scenarios

10.4 The role of personnel in the performance feedback framework

The role of key personnel in the provision of performance feedback is fundamentally important, since this should not be a direct line manager. It is envisaged that initially the Lecturer Practitioner, Practice Educator or Practice Development Facilitator would be in an ideal position to provide such feedback, as practice development is likely to be a key element of their role. The Nurse Lecturer should also be involved with practice-based education, which will ensure that they are up to date with current practice. However, if the framework became a more established component of practice within the NHS, across all professional disciplines, it is envisaged that eventually the process could be managed by peer review. Ensuring that practice is up to date and evidence based is an issue that affects everybody across all areas of healthcare, as practitioners should want to make sure that they provide the best possible care for their critically ill patients.

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APPENDIX 1:

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An evaluation of a teaching intervention to improve the practice of endotracheal suctioning in intensive care units

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Summary

• Endotracheal suctioning is a frequently performed procedure that has many associated risks and complications. It is imperative that nurses are aware of these risks and are able to practise according to current research recommendations.

• This study was designed to examine to what extent intensive care nurses' knowledge and practice of endotracheal suctioning is based on research evidence, to investigate the relationships between knowledge and practice, and to evaluate the effectiveness of a research-based teaching programme.

• This quasi-experimental study was a randomized, controlled, single-blinded comparison of two research-based teaching programmes, with 16 intensive care nurses, using non-participant observation and a self-report questionnaire.

• Initial baseline data revealed a low level of knowledge for many participants, which was also reflected in practice, as suctioning was performed against many of the research recommendations.

• Following teaching, significant improvements were seen in both knowledge and practice. Four weeks later these differences were generally sustained, and provide evidence of the effectiveness of the educational intervention.

• The study raised concern about all aspects of endotracheal suctioning and highlighted the need for changes in nursing practice, with clinical guidelines and focused practice-based education.

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Introduction

BACKGROUND

The principal goal of airway management is to establish and maintain a patient airway in order to ensure adequate alveolar ventilation, oxygenation and gas exchange (Dean, 1997). Endotracheal suctioning is an essential aspect of airway management and is a routine and necessary nursing intervention (Wainwright & Gould, 1996; Wood, 1998a). However, this has been identified as a potentially dangerous procedure, with many associated risks and complications. These range from trauma and bronchoconstriction to hypoxaemia, cardiac arrest and death (Czarnik *et al.*, 1991; Fiorentini, 1992; Raymond, 1995).

In view of such hazards, there is an increasing body of evidence to suggest how and when suctioning should be performed (Glass & Grap, 1995; Wainwright & Gould, 1996; Wood, 1998a). However, in spite of the available research evidence, clear protocols or guidelines are often lacking in the practice setting.

PURPOSE OF THE STUDY

The ability to analyse and synthesize empirical evidence related to nursing practice has become increasingly important (Parkin, 1998; Warner *et al.*, 1998; Witejunge & Baldock, 1998). Indeed, one of the goals of nursing is to strengthen the scientific foundation upon which to base practice (Taylor-Piliae, 1998). Over the past 5 years the NHS Research and Development Strategy has increased the evidence base regarding cost and clinical effectiveness (NHSE, 1996a). Consequently, health policy is fully committed to the evidence-based practice and clinical effectiveness initiative (NHSE, 1996a,b,c), which has led to the production of clinical guidelines and protocols for interventions. The purpose of the evidence-based practice initiative is to enable nurses to be competent in making sound clinical judgements and decisions about interventions that are based on empirical evidence as opposed to ritual or tradition (Felch & Scanlon, 1997; Muir Gray, 1997; Nolan *et al.*, 1998). However, the problems with implementing research findings that are based on empirical evidence and producing clinical guidelines and protocols in nursing have also been documented (Felch & Scanlon, 1997; Muir Gray, 1997; Nolan *et al.*, 1998). These include issues such as lack of motivation or knowledge of the most up to date or current evidence. French (1999) argues that even in the late 1990s many nursing practices were still based on experience, ritual, intuition and common sense and, despite an increasing body of knowledge about the effectiveness of certain nursing interventions, there remains a discrepancy between theoretical knowledge and practical application.

Endotracheal suctioning is one intervention that should be based on research evidence, as there have been a large number of studies published on the various aspects of this routine procedure. However, although one study has examined the indications for initiating suctioning (Copnell & Fergusson, 1995) and one further study investigated nurses' assessment skills prior to suctioning (Wood, 1998b), no other studies appear to have investigated how certain aspects of the suctioning procedure are performed in practice. This became the main factor influencing the decision to undertake this study.

Review of the literature

In the healthy patient the action of ciliated cells, the local immune system and the cough reflex are essential for destroying and removing microorganisms and clearing debris from the lungs. However, critically ill patients are often intubated and the endotracheal tube bypasses the normal physiological processes and inhibits the cough reflex. Hence, periodic suctioning is required to clear secretions and prevent atelectasis or alveolar collapse (Odell *et al.*, 1993; Wainwright & Gould, 1996). Endotracheal suctioning should always be performed when clinically indicated and preceded by a comprehensive assessment of the patient (Wood, 1998a,b).

PRIOR TO SUCTIONING

Informing the patient and encouraging their participation has been identified as a strategy for reducing stress and anxiety and maximizing the outcome of endotracheal suctioning (Young, 1984; Fiorentini, 1992). Endotracheal suctioning has frequently been associated with hypoxaemia, which can lead to cardiac dysrhythmias, hypotension, cardiac arrest and death (Marx *et al.*, 1968; Shim *et al.*, 1969; Boutros, 1970). Strategies to minimize these risks include hyperoxygenation and hyperinflation. Hyperoxygenation involves the administration of a fraction of inspired oxygen (FiO_2) of greater than pre-suctioning levels, which is delivered by either a manual re-breath bag or via the ventilator circuit (Glass & Grap, 1995). This may be either by pre-oxygenation or insufflation during suctioning. Although not without risks, most studies have shown both methods to be effective (Adlkofer & Powaser, 1978; Lucke, 1982; Rogge *et al.*, 1989). Hyperinflation involves inflating the lungs with a larger tidal volume, which can also be delivered either by a manual re-breath bag or via the ventilator circuit (Wood, 1998a). Most authors recommend a hyperinflation volume of 100–150% (Grap *et al.*, 1994).

The instillation of normal saline prior to suctioning has become common practice in many intensive care units (Ackerman, 1993; Ackerman *et al.*, 1996). However, as Bostick & Wendelgass (1987) argue, this is an example of a widely practised intervention that is not supported by research. In fact there is considerable research evidence against its use (Blackwood, 1999). Theoretically, saline is used to loosen secretions. However, there is evidence that sputum and saline do not mix *in vitro* (Ackerman, 1993; Blackwood, 1999). The potential detrimental effects of saline instillation include a fall in PaO_2 (Ackerman & Gugerty, 1990), an increased risk of infection (Rutala *et al.*, 1984) and a failure to remove all saline during suctioning (Hanley *et al.*, 1978).

SUCTIONING

Suction catheters are manufactured in polyvinyl chloride and do not require lubrication (Pierce, 1995). Some studies suggest that catheters with a single side hole produce more trauma than those with multiple side holes (Link *et al.*, 1976; Young, 1984). Large size catheters have been shown to increase the risk of trauma due to greater mucosal contact. It is widely accepted that the external diameter of the suction catheter should not exceed one half of the internal diameter of the endotracheal tube (Odell *et al.*, 1993; Glass & Grap, 1995).

Stimulation of the vagus nerve during catheter insertion may lead to alterations in heart rate and rhythm. Ashurst (1992) suggests that if the patient is able to cough, inserting the catheter just beyond the end of the endotracheal tube can reduce pain and trauma. However, in sedated or paralysed patients it may be necessary to advance the catheter beyond this. Most authors recommend advancing the catheter to the carina (which is felt by resistance or on stimulating a cough) and then withdrawing the catheter 1 cm before applying suction (Pierce, 1995; Dean, 1997; Wood, 1998a).

High levels of negative pressure have been shown to cause mucosal damage, hypoxaemia and atelectasis (Czarnik *et al.*, 1991). Limiting pressures to between 80 and 150 is recommended (Luce *et al.*, 1993; Boggs, 1993). This should be continuous, as intermittent suctioning may be ineffective. Catheter rotation may also lead to trauma.

Many researchers recommend that endotracheal suctioning should take between 10 and 15 s to perform; longer durations are associated with an increased risk of hypoxaemia because the patient is often off ventilatory support (Allen, 1988; Boggs, 1993).

Wood (1998a,b) argues that one variable that may contribute to the risk of complications is the number of suction passes in one suctioning event. Some authors recommend allowing oxygen saturation to return to pre-suctioning parameters between passes (Smith, 1993), but many say that no more than three passes should be made per episode (Fiorentini, 1992; Glass & Grap, 1995).

Maintenance of asepsis is an essential consideration as suctioning is an invasive procedure and is associated with an increased risk of infection. Although there is considerable debate as to whether sterile or non-sterile gloves are used (or indeed whether suctioning is a sterile or 'clean' procedure), there is a general consensus that the following infection control measures should be employed:

- Hand hygiene, both before and after suctioning (gloves are no substitute for this);
- Gloves should be used for all patients;
- Aprons should be used for all patients;
- Goggles should be used for all patients (Wood, 1998a).

POST-SUCTIONING

Reconnecting the patient to ventilatory support should take place within a maximum period of 10 s in order to prevent hypoxaemia (Adam & Osborne, 1997). Assessment should include monitoring heart rate and rhythm, colour and oxygenation.

Chest auscultation should also be performed and an assessment of air entry and breath sounds. In addition, ventilatory settings and alarms should be checked and/or reset and if FiO_2 levels were increased, these should be reduced to pre-suctioning levels. Sputum should be observed for colour, odour, volume and consistency, and findings documented. On completion of the procedure, verbal reassurance should be given to the patient. A summary of the actions and research recommendations is presented in Table 1.

IMPLICATIONS OF THE LITERATURE ON THE STUDY

The literature highlighted numerous factors that may increase the risk of endotracheal suction-related complications. The responsibility for this intervention rests with

Table 1 Summary of research recommendation for suctioning

Actions	Risks	Recommended practice
Prior to suctioning		
Assessment of patient	Suctioning that is not clinically indicated may cause unnecessary anxiety and stress and provoke life-threatening side-effects	Auscultate chest for air entry and signs of sputum in airways. Monitor oxygenation using pulse oximetry.
Reduction of stress and anxiety	Stress and lack of co-operation may reduce effectiveness of the procedure and potentiate risks	Explanation of the procedure and encouraging patient participation (Young, 1984; Fiorentini, 1992). Pain relief if required.
Prevention of hypoxaemia	May cause cardiac dysrhythmias, cardiac arrest and death (Boutros, 1970; Shim *et al.*, 1969; Marx *et al.*, 1968).	Strategies to minimize risk of hypoxia: Hyperoxygenation (Glass & Grap, 1995; Rogge *et al.*, 1989). Hyperinflation (Wood, 1998a; Grap *et al.*, 1994). Hyperinflation and hyperoxygenation (Goodnough, 1985; Stone *et al.*, 1989; 1991)
Infection control measures	Suctioning is an invasive procedure and is therefore associated with an increased risk of infection.	Maintenance of asepsis is an essential consideration. Although there is debate as to whether sterile or non-sterile gloves are used, there is general consensus that the following infection control measures should be employed: Hand hygiene, both before and after suctioning (gloves are no substitute for this). Gloves should be used for all patients. Aprons should be used for all patients. Goggles should be used for al patients (Wood, 1998a).
Catheter selection	Large size catheters have been shown to increase the risk of trauma due to greater mucosal contact. Catheters with a single side hole produce more trauma than those with multiple side holes (Link *et al.*, 1976; Young, 1984).	The external diameter of the suction catheter should not exceed one half of the internal diameter of the endotracheal tube (Odell *et al.*, 1993; Glass & Grap, 1995). Suction catheters are manufactured in polyvinyl chloride and do not require lubrication (Pierce, 1995).
Suctioning		
Depth of insertion	Stimulation of the vagus nerve may lead to alterations in heart rate and rhythm. If the patient is able to cough, inserting the catheter just beyond the end of the endotracheal tube can reduce painand trauma (Ashurst, 1992). In sedated paralysed patients it may be necessary to advance the catheter beyond this.	Most authors recommend advancing the catheter to the carina (which is felt by resistance or on stimulating a cough) and then withdrawing the catheter 1 cm before applying suction.
Negative pressure	High levels of negative pressure have been shown to cause mucosal damage, hypoxaemia and atelectasis (Czarnik *et al.*, 1991). Intermittent suctioning may be ineffective. Catheter rotation may also lead to trauma.	Limiting pressures to between 80 and 150 mm Hg is recommended – this should be continuous.
Duration of suctioning	Longer durations are associated with an increased risk of hypoxaemia, as the patient is often off ventilatory support, or mucosal damage (Allen, 1988; Boggs, 1993).	Many researchers recommend that endotracheal suctioning should take between 10 and 15 s to perform (Allen, 1988; Boggs, 1993).
Number of suction passes	One variable that may contribute to the risk of complications is the number of suction passes in one suctioning event (Wood, 1998a)	Some authors recommend allowing the oxygen saturation to return to pre-suctioning parameters between passes (Smith, 1993) but many say that no more than three passes should be made per episode.

Table 1 *(Contd.)* Summary of research recommendation for suctioning

Actions	Risks	Recommended practice
Post-suctioning Reconnection of patient to non-ventilatory support/oxygen/humidification	hypoxaemia if not re-connected promptly to non-ventilatory support/oxygen/humidification	Reconnect patient within a maximum of 10 s
Assessment of patient	Suctioning may have been ineffective in removing sputum from the airways. Hypoxaemia may cause cardiac dysrhythmias	Auscultate chest for air entry and signs of sputum in airways. Assess heart rate and rhythm, colour and oxygenation. Assess sputum for colour, odour, volume, consistency and document findings. Reduce FiO_2 to pre-suctioning levels.
Reduction of stress and anxiety	Patient may be uncomfortable, anxious, stressed following the procedure.	Assess patient for discomfort/pain. Verbally reassure patient and administer pain relief if required.

Table 2 Major categories of performance observed

Prior to suctioning	Patient preparation, auscultation, hyper-oxygenation, hyperinflation, normal saline instillation, infection control measures and maintenance of asepsis.
Suctioning	Size of endotracheal tube and suction catheter, negative suction pressure, technique of catheter withdrawal, duration of procedure, safety checks and the number of suction passes.
Post-suctioning	Reconnection of ventilator, auscultation, assessment of colour, oxygenation and sputum, ventilatory parameters and alarm resetting, reduction of FiO_2 and verbal reassurance to the patient.

the critical care nurse and any knowledge deficits may result in poor practice and dangerous suctioning techniques. In order to be accountable in performing this basic skill, each nurse should be aware of the controversies and potential hazards, and be able to implement safer suctioning practices (UKCC, 1992). However, it is hypothesized that nurses may be unaware of these risks and that practice may be based on rituals and tradition as opposed to empirical evidence.

Method

AIMS

The principal aims of this study were:

1 To investigate to what extent intensive care unit nurses' knowledge and practice of endotracheal suctioning is based on research evidence;

2 To investigate the effectiveness of a research-based teaching intervention to improve intensive care unit nurses' knowledge and practice of endotracheal suctioning.

DESIGN

This study took place in a large intensive care unit. The teaching programme about endotracheal suctioning was designated as the independent variable for study, and this was delivered to the experimental group (the intervention arm of the study; Fig. 1). The control group received an alternative teaching programme that focused on humidification. The nurses were randomly assigned to each group, in order to minimize selection bias, as recommended by Hsu (1989) and Stewart & Parmar (1996). The participants in the experimental group also served as their own controls, as they were assessed before and after teaching. Data collection was 'blind' without knowledge of each participant's research group.

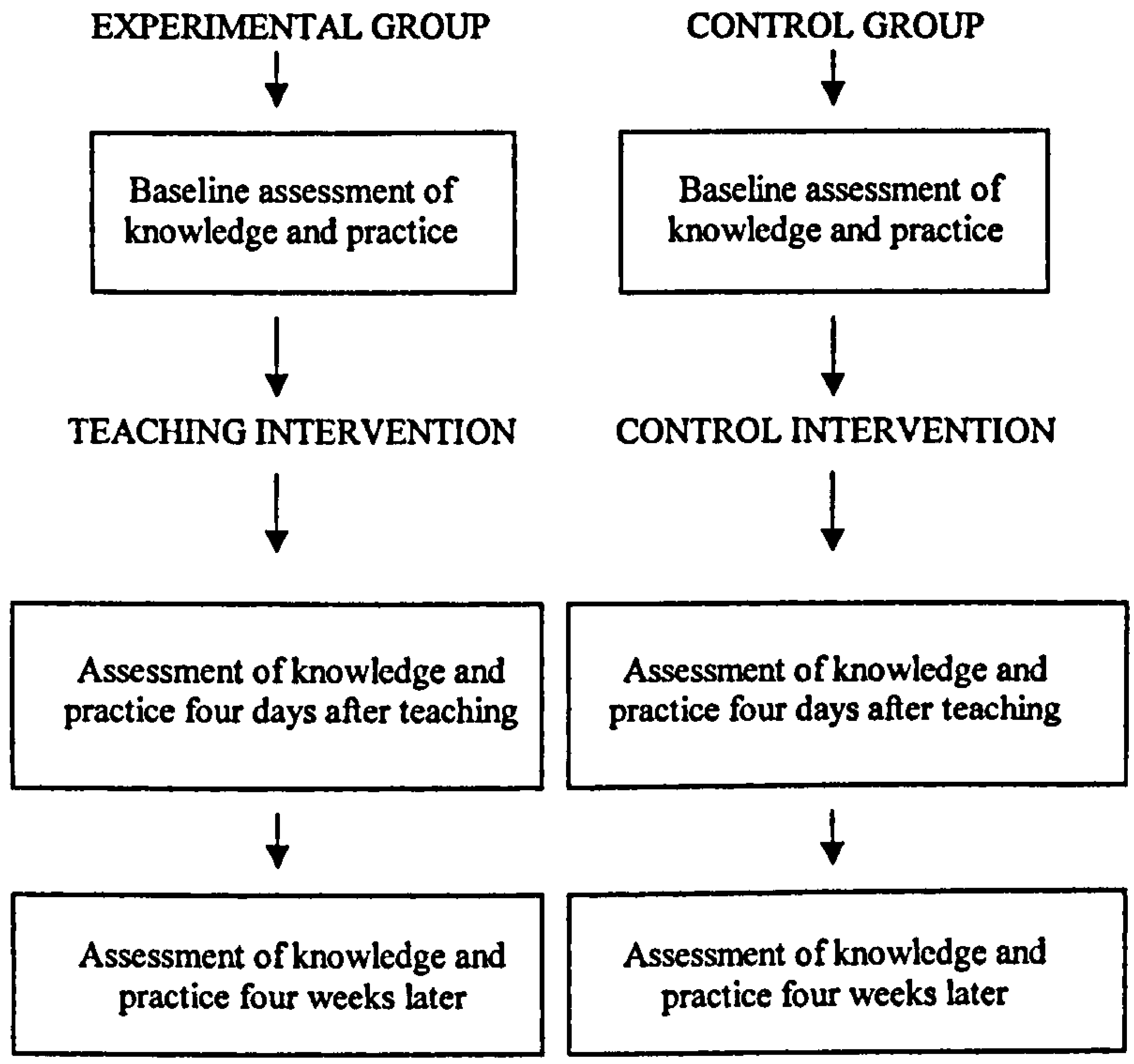

Figure 1 Diagram to illustrate design.

THE SAMPLE

The sample consisted of 16 nurses. Four nurses per grade were selected at random from the off duty rota, in order for the sample to be representative of the range of intensive care unit nurses' grades and length of experience. However, those who were currently undertaking clinical awards, such as the English National Board 100 Course (ENB 100) were excluded from the study. The culture of the unit is one of innovation, with a strong emphasis on education, research and development, and commitment to evidence-based practice.

In quasi-experimental work there is the possibility of making a Type I or Type II error. The risk of a Type I error was minimized by accepting a 5% level of significance. However, the risk of Type II errors is only reduced by power analysis. In this study, the sample was selected according to the number of practitioners available to participate in the study and to be randomized accordingly, as opposed to a specific power calculation. Moreover, the study was intended as a pilot for future work on a larger scale.

RANDOMIZATION

Participants were randomly assigned the study groups in order to minimize selection bias. A member of the intensive care unit's staff development team undertook the randomization procedure. Each participant was observed on more than one occasion, because statistical regression can occur if subjects have a 'bad' day, leading to a shift in mean scores (Campbell & Stanley, 1966). The major categories of performance that were observed are detailed in Table 2. Data were collected over a short period of time. Once ethical approval had been obtained and the randomization procedure completed, the participants were approached and consent was obtained. During the observations it was emphasized that the researcher would be unable to participate in the procedure or answer any questions. Each nurse was given a participant information sheet, which gave details about the topic under investigation. However, this was purposefully vague in an attempt to gain an accurate reflection of practice and to minimize the observer effect.

RESEARCH INSTRUMENTS

Data were collected by two methods, a knowledge-based questionnaire and non-participant observation. Non-participant observation was adopted as an additional method because as Swanwick (1994) suggested, different results might emerge from the two methods, with nurses demonstrating a level of knowledge that is not reflected in practice.

The questionnaire was developed according to the process outlined by McColl (1993). Specific information to be sought was identified from the study aims and research questions. The questionnaire was administered in the presence of the researcher, in order to avoid potential contamination within the sample. Indeed, careful consideration was given to the risk of contamination between the groups. No questionnaires were left unattended and all were completed in the presence of the researcher. Participants in the experimental group were unaware of the composition of the control group and with such a small sample from a unit that has a large nursing establishment, the chances of finding out this information seemed low.

The structured observation schedule was developed from details included in the questionnaire, from published and unpublished instruments (Porter *et al.*, 1986; Oliver & Redfern, 1991; Roe, 1993; Pretzlik, 1994; Day, 1995) and from pilot work. The schedule was designed in a similar format to the questionnaire, which enabled comparisons to be drawn between knowledge and practice.

VALIDITY AND RELIABILITY

The research instruments were distributed for appraisal to a range of senior intensive care unit practitioners who were unconnected to the study site, and other experts in the field. Both tools were amended accordingly.

Inter-rater reliability of the observation schedule was tested using a second observer during the pilot study (Cohen, 1968). Percent agreements are easy to calculate, but fail to allow for chance agreements or commission vs. omission errors (Topf, 1986). Kappa measurements have the advantage of controlling for chance agreements (LeMay, 1992). Percent agreements ranged from 75 (for one item only) to 100%, and kappa measurements from 0.54 (for one item only) to 1.0, indicating an acceptable level of agreement (Hartman, 1977; House *et al.*, 1981).

TEACHING INTERVENTIONS

Two teaching programmes were produced: 'endotracheal suctioning' for the experimental group, and 'humidification during mechanical ventilation' for the control group. These were both scheduled to take place over a 2-hour period, so that all groups would receive the same amount of educational input. For each programme, a detailed plan, learning outcomes and practice outcomes were identified. A variety of teaching methods were utilized, including both didactic and interactive approaches, and practical bedside demonstrations.

Teaching took place in small groups because this has been associated with greater knowledge retention (Marsden, 1989; Greig *et al.*, 1996). An independent lecturer who was an expert in both subject areas carried out the teaching interventions.

ETHICAL ISSUES

Each participant was given an information sheet, which informed him or her about the study and that they could withdraw at any time. Written consent was also obtained. In relation to the observations, it was explained to each participant that researcher intervention would be necessary in the event of dangerous or consistently poor practice. Ethical approval was obtained from the School Research Ethics Committee.

PILOT STUDY

The pilot study took place once ethical approval had been obtained. Eleven nurses completed the questionnaire. These were selected because they had already been identified as being excluded from the main study. Following pilot work a number of problem areas were identified and the questionnaire was modified and subsequently re-piloted with 12 nurses.

Similarly, the observation schedule was piloted with three nurses initially. This was also modified and re-piloted. The schedule was also tested for inter-rater reliability at this time and no further modifications were made.

CODING AND SCORING

The data were coded and entered onto a computer system running MINITAB for windows (release 12). The responses were scored and arranged in ranked order.

DATA ANALYSIS

Frequency ratings and percentages were calculated for nominal level data. Ranges, means and medians were calculated for ordinal level data (the scores for knowledge and practice). The experimental hypotheses were tested using non-parametric statistical tests. Ordinal level data were analysed by analysis of variance (ANOVA) on the ranked scores. A significance level of $P < 0.05$ was accepted as statistically significant.

Findings

KNOWLEDGE AT BASELINE LEVEL

At baseline level none of the participants demonstrated complete accuracy for all components of suctioning. The maximum possible score was 25 points and possible scores ranged from 13–20.

Most participants ($n = 13$) gave an appropriate rationale for suctioning. No one indicated that this should take place routinely or at set time intervals. Areas of concern related mainly to normal saline instillation because all felt that it was acceptable to instil normal saline. However, most ($n = 11$) were aware of the associated risks and complications.

Other concerns related to the catheter size; only six participants were able to accurately calculate an appropriately sized suction catheter for the size of endotracheal tube. Seven participants indicated that a larger catheter should be used. Few ($n = 6$) were aware of the recommended suctioning pressures. Similarly, the technique and application of negative pressures were generally not known.

PRACTICE AT BASELINE LEVEL

No participants demonstrated complete accuracy in their endotracheal suctioning techniques. The maximum possible score for practice was 25 points. Scores ranged from six to 15, with 13 participants (81%) scoring below the 50 percent level.

Although many participants ($n = 13$) had indicated that suctioning would only be performed following a comprehensive pulmonary assessment, only one actually performed auscultation in practice.

The majority gave very little information to the patient to explain the procedure, except for a very brief statement:

'There is a tube coming down now ...'

Other areas of concern related to the limited use of hyper- or pre-oxygenation, and limited adherence to universal precautions, as few participants ($n = 4$) washed their hands before or after suctioning, and few wore goggles ($n = 5$). All 16 participants used a catheter that was too large for the size of endotracheal tube and many suctioned using pressures of 150–199 mm Hg (or 20–26.5 kpa), which is higher than recommended. The duration of the procedure was also longer than recommended; as many 12 participants took 20 s or longer to suction. A summary of baseline findings is presented in Table 3.

FOLLOWING TEACHING

It was hypothesized that the nurses who received the teaching programme about endotracheal suctioning would demonstrate a higher level of research-based knowledge and practice than those who did not receive the teaching programme.

Table 3 Summary of findings from the 16 nurses at baseline level

Research recommendations	Knowledge (n = 16)	Observed practice (n = 16)
Prior to suctioning		
Auscultation	13	1
Patient preparation	15	7
Pre-oxygenation	13	4
Avoidance of saline	0	12
Hand washing before	16	4
Use of aprons	4	9
Use of goggles	16	5
Suctioning		
Accurate catheter size	6	0
Accurate suction pressures	6	0
Continuous pressure	10	8
Accurate duration	4	0
Some form of safety check	15	3
Post-suctioning		
Auscultation	13	0
Assessment of colour	16	1
Reconnection <10 s	15	16
Checking ventilation settings	10	2
Patient reassurance	2	4
Hand washing after	16	2

KNOWLEDGE

No significant differences were found ($P = 0.35$) between the groups and the nurses' scores at baseline level when compared by ANOVA. However, highly significant differences were found 4 days after teaching ($P < 0.01$). Post-teaching, the experimental group had a mean knowledge score of 22.9 with a median score of 23. In contrast, the control group had a mean score of 16.8 and a median score of 17.5.

PRACTICE

At initial baseline assessment, no significant differences were found ($P = 0.36$) between the groups' and the nurses' scores when compared by ANOVA. However, highly significant differences were found following the teaching intervention ($P < 0.01$). Post-teaching, the mean observation score for the experimental group was 22.37, with a median score of 22.50. In contrast, the control group had a mean score of 11.81 and a median score of 11.75.

Areas of particular concern identified at baseline level were largely addressed, with improvements seen for the majority of interventions. Notably, appropriately sized suction catheters were used by each participant, accompanied by recommended suctioning pressures and durations. There was a greater compliance with universal precautions, and more attention to hand washing and the use of goggles. Greater attention was given to preparing the patient and assessing parameters post-suctioning. A summary of these post-teaching findings is presented in Table 4, which illustrates the number of participants who practised according to current research evidence.

IMPROVEMENTS OVER TIME

It was also hypothesized that the nurses who received the teaching programme would sustain a higher level of research-based knowledge and practice of endotracheal suctioning over time.

KNOWLEDGE

Four weeks later, the subjects in the experimental group were still able to demonstrate a higher level of research-based knowledge than those in the control group, whose knowledge remained unchanged from that at baseline level or, in some instances, deteriorated. The experimental group sustained a mean knowledge score of 22.87 and a median of 23. The control group's mean score was 16.75 and the median remained unchanged at 17.50. These differences were still highly significant ($P < 0.01$).

PRACTICE

Four weeks later, the subjects in the experimental group were still able to demonstrate a higher level of research-based practice in their endotracheal suctioning techniques than those in the control group, whose practice remained unchanged from that at baseline level or, in some instances, deteriorated. The mean observation score for the experimental group was 21.00, with a median of 21.50. This represented a fall in the mean score of 1.3 points. The control group's mean score was 11.12 and the median remained largely unchanged at 11.37. These differences were still highly significant ($P < 0.01$). Score differences for each group before and after teaching are presented in Figs 2 and 3 for knowledge, and Figs 4 and 5 for practice.

Discussion

The aim of the study was to investigate to what extent intensive care unit nurses' knowledge and practice of endotracheal suctioning is based on empirical evidence. It was hypothesized that the nurses who received the teaching programme about suctioning would demonstrate a higher level of knowledge and practice than those who received an alternative teaching programme. The results

Table 4 Summary of findings after the teaching interventions

	Experimental group (n = 8)		Control group (n = 8)	
Research recommendations	Knowledge	Practice	Knowledge	Practice
Prior to suctioning				
Auscultation	8	8	6	0
Patient preparation	8	8	8	8
Pre-oxygenation	7	8	7	2
Avoidance of saline	3	8	0	6
Hand washing before	8	8	8	1
Use of aprons	8	8	7	7
Use of goggles	8	8	7	2
Suctioning				
Accurate catheter size	8	7	2	0
Accurate suction pressures	8	8	2	0
Continuous pressure	8	7	4	4
Accurate duration	5	8	0	0
Some form of safety check	7	8	8	0
Post-suctioning				
Auscultation	8	7	7	1
Assessment of colour	8	5	8	1
Reconnection < 10 s	7	8	7	8
Checking ventilation settings	7	6	7	2
Patient reassurance	4	8	0	3
Hand washing after	8	8	8	1

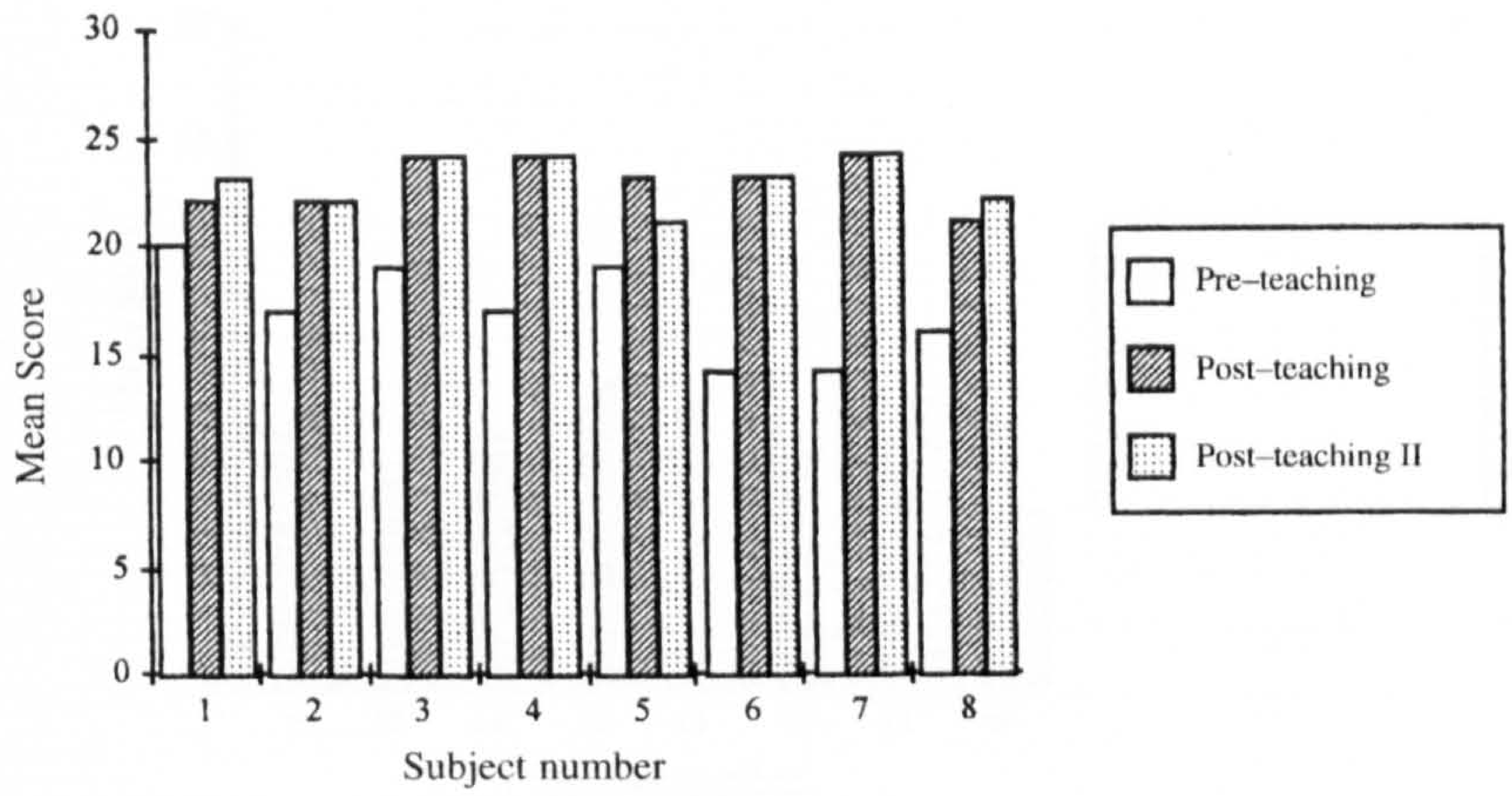

Figure 2 Comparison of knowledge scores at pre- and post-teaching: experimental group.

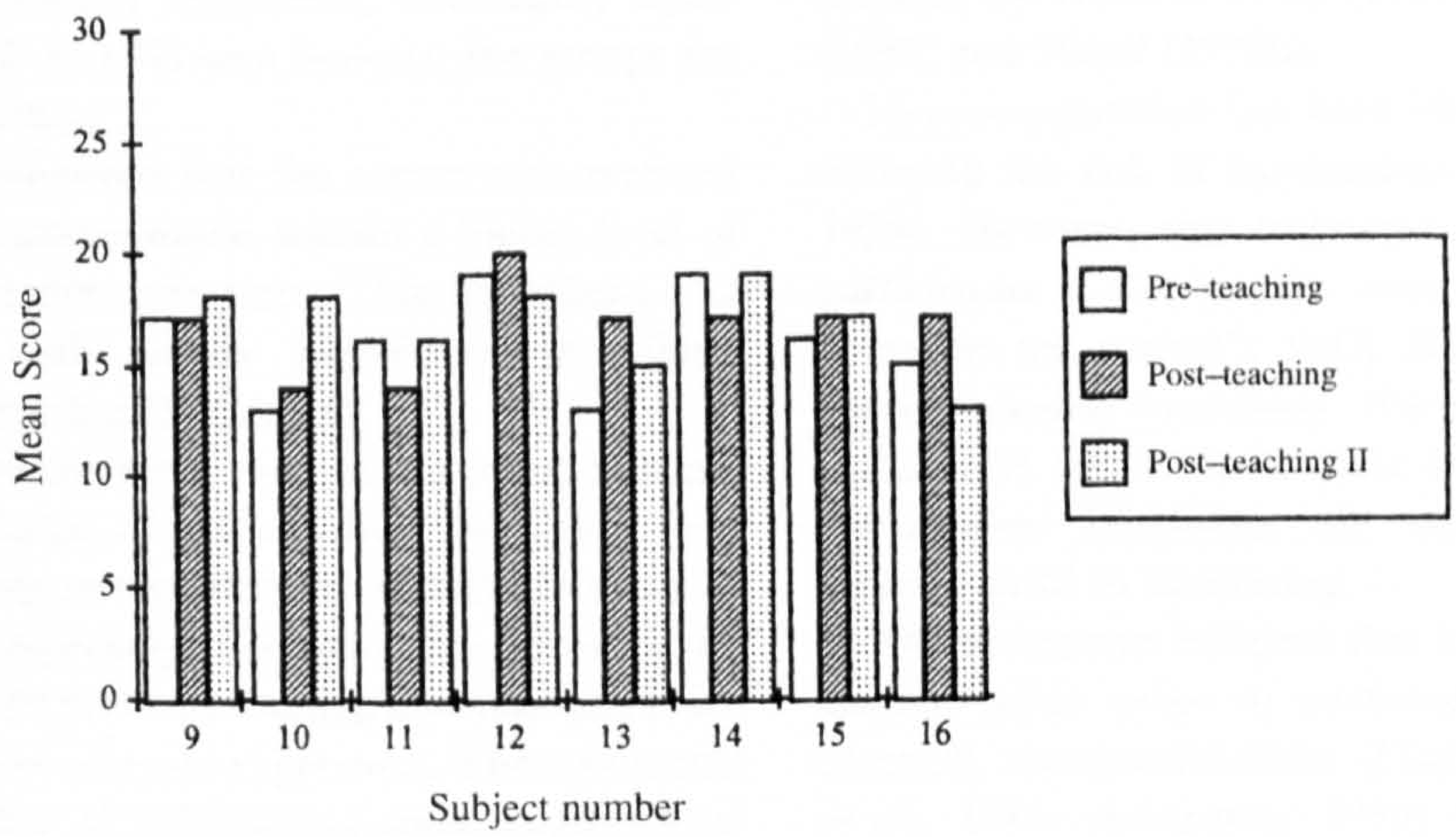

Figure 3 Comparison of knowledge scores at pre- and post-teaching: control group.

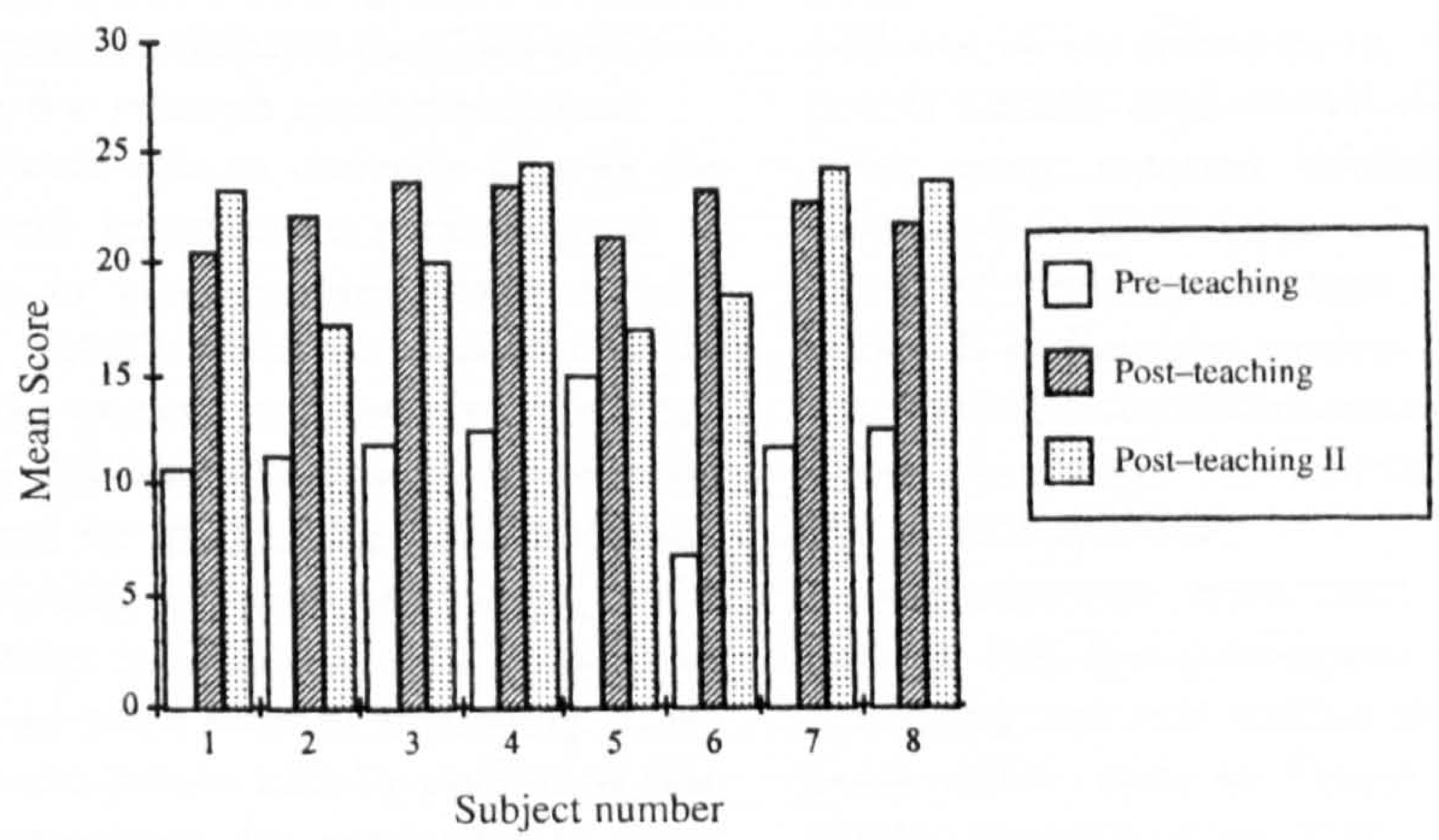

Figure 4 Comparison of observation scores at pre- and post-teaching: experimental group.

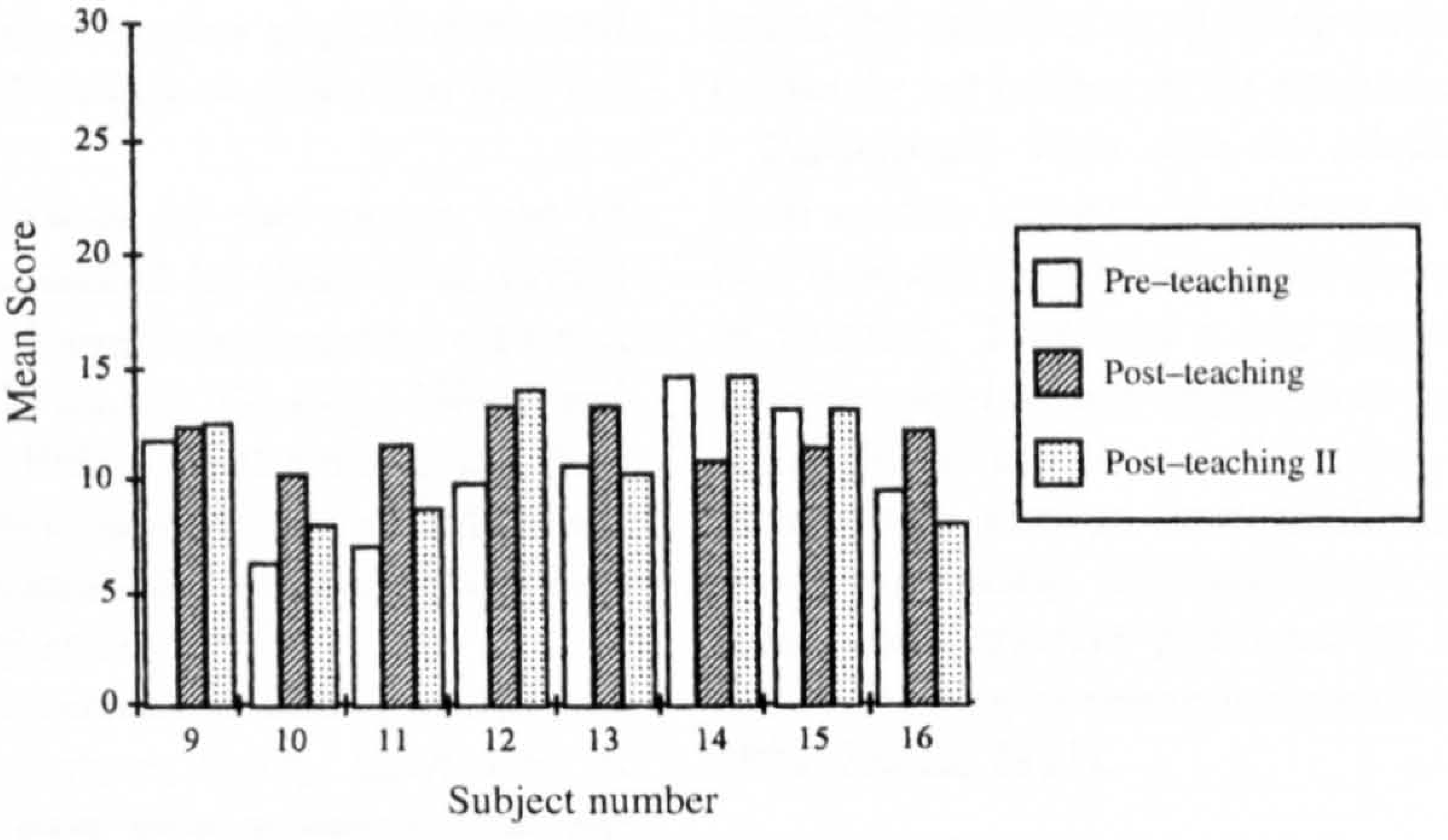

Figure 5 Comparison of observation scores at pre- and post-teaching: control group.

support this experimental hypothesis, with highly significant differences ($P < 0.01$) seen between the groups for knowledge and practice.

It was also hypothesized that the nurses who received this teaching programme would sustain a higher level of knowledge and practice over time. This hypothesis was also supported, with highly significant ($P < 0.01$) improvements 1 month after teaching.

The findings demonstrated that, at the initial baseline assessment, knowledge of endotracheal suctioning was generally poor. Only one participant achieved a score of 80%. This was especially disappointing because the majority had received previous training and most had more than 5 years intensive care unit experience. There have also been a large number of publications about endotracheal suctioning in recent years (Dean, 1997; Simmons, 1997; McKelvie, 1998; Wood, 1998a,b; Blackwood, 1999).

The findings also demonstrated that practice was poor at the baseline assessment. These findings were extremely worrying because for some participants they indicated that practice was based on few research recommendations.

Many participants were able to correctly identify the information that should be given to patients prior to suctioning. However, in practice, only seven actually prepared the patient verbally. This is a major concern because informing the patient and encouraging their participation has been identified as a strategy for relieving distress and anxiety and for maximizing the effectiveness of endotracheal suctioning (Demers & Saklad, 1973; Fiorentini, 1992). Many participants were aware that auscultation should take place prior to suctioning. However, in practice only one person actually performed this. This may suggest a tendency for suctioning to occur routinely, rather than when clinically indicated as recommended by Glass & Grap (1995), Copnell & Fergusson (1995) and Wood (1998b).

Hyperoxygenation has been identified as a strategy for reducing the risk of hypoxaemia (Wainwright & Gould, 1996). However, this technique was only used by four participants at the baseline assessment. On a number of occasions the patient's SpO_2 fell transiently, by 3 or 4 percent during suctioning. Such a fall in SpO_2 might perhaps be inevitable in some critically ill patients; this nevertheless highlights the need to implement this strategy prior to suctioning.

All participants believed that it was acceptable to instil normal saline prior to suctioning. This is against all research recommendations (Hanley *et al.*, 1978; Rutala *et al.*, 1984; Ackerman, 1990) with little evidence to suggest that it increases sputum removal (Ackerman & Gugerty, 1990; Blackwood, 1999). Blackwood (1999) argues that even after 25 years of empirical work in this area, inconsistencies remain and individuals cite anecdotal evidence of its effectiveness. Although few participants ($n = 4$) actually used normal saline at the baseline assessment, many reported informally that they had been instructed to instil large volumes of normal saline (in excess of 5 ml) by members of other professional disciplines. It is, however, unclear as to whether these nurses are ignoring research recommendations, on the instruction of other health care professionals, or are simply unaware of the current evidence.

Inconsistencies were seen in relation to infection control; only four participants washed their hands before suctioning and two washed them afterwards. This supports earlier work by Gould *et al.* (1996), who found similar inconsistencies. Subjects were aware that gloves and goggles should be used during suctioning. However, although gloves were always worn, few goggles were used or indeed seen at the bedside, which suggests that they are not routinely worn.

Few participants were aware of the correct size of suction catheter, as recommended by Odell *et al.* (1993) and Glass & Grap (1995). Larger sized suction catheters have been associated with trauma (Young, 1984), and hypoxaemia (Odell *et al.*, 1993). Furthermore, the duration of suctioning was longer than recommended, which has been associated with mucosal damage and hypoxaemia (Sackner *et al.*, 1973; Odell *et al.*, 1993).

Few safety checks were performed during suctioning, and any deterioration in colour, SpO_2, heart rate or rhythm could potentially have gone undetected. It was encouraging to note that 15 out of 16 participants reconnected the patient to the ventilator within 10 s of completing the suctioning procedure. However, although all were aware that this should be followed by a comprehensive assessment, according to the American Association of Respiratory Care (1993) recommendations, no participants performed this in practice. This suggests that a full pulmonary assessment is not routinely undertaken on completion of this procedure. Similarly, providing verbal reassurance to the patient was not generally seen in practice. This apparent lack of consideration for some of the post-suctioning events may reflect the lack of literature relating to these interventions. Nevertheless, maintaining patient comfort and ensuring effective communication must surely be an important aspect of the critical care nurse's role (Viney, 1996).

FOLLOWING THE TEACHING INTERVENTIONS

Following teaching, knowledge and practice improved significantly the experimental group. These improvements were generally sustained over time. However, after 4 weeks, one participant's practice score fell from 85% to 68%, and one from 89% to 69%, highlighting a deterioration of up to 20%.

All of the pre-suctioning events were accurately reported and performed in practice. However, interestingly, five participants in the experimental group still believed that it was acceptable to instil normal saline prior to suctioning (although none actually did in practice). There are two possible explanations for this. Firstly, it is possible that, in spite of research recommendations, nurses still feel that this is a controversial issue and, as Blackwood (1999) suggests, continue to provide anecdotal evidence to support its use. It is also possible that because other health care professionals promote normal saline instillation, nurses still believe that it is effective. This supports the argument of Hunt (1996) that one of the obstacles to applying research to practice is that nurses do not believe in the research.

Participants were able to calculate an appropriately sized suction catheter in relation to the size of endotracheal tube and the majority used the correct size of catheter in practice. This was a big improvement because the baseline observations highlighted a tendency for 'green sized 14FG' catheters to be used, which indicates that nurses were now at least thinking about their practice before suctioning. Similarly, once nurses were aware of appropriate negative pressures for suctioning they practised according to research recommendations (Odell *et al.*, 1993; Smith, 1993).

IMPLICATION FOR EDUCATION

The findings were encouraging and illustrate the effectiveness of the educational intervention. However, small group teaching and practical bedside demonstrations are likely to have played a major role in contributing to these findings (Marsden, 1989; Greig *et al.*, 1996).

The problems in retaining knowledge and skills over time have long been documented (Wright *et al.*, 1989; Corner & Wilson-Barnett, 1992; Moser & Coleman, 1992; Coyler & Kamath, 1999). In their evaluation of an educational intervention pertaining to the newly qualified nurse and the cancer patient, Corner & Wilson-Barnett (1992) demonstrated that although initially there were substantial benefits, these were less obvious 3 months later. Similarly, many of the studies relating to cardiopulmonary resuscitation skills retention have demonstrated that practice starts to decline as early as 2 weeks after initial training (Plank & Steinke, 1989; Rivera-Tovar & Jones, 1990; Moser *et al.*, 1990; Moser & Coleman, 1992). At the 4-week post-teaching knowledge assessment, the experimental scores remained high. However, four subject's practice scores had already started to decline. Further assessments, at 3-monthly intervals, would have enabled these issues to be more closely examined. It should also be acknowledged that the design of this study might have contributed to improvements in practice in general because the nurses were aware that a study relating to endotracheal suctioning was being conducted on the unit and, whether consciously or subconsciously, this might have influenced practice. This became evident following the post-teaching assessment. Although the control group's scores did not alter significantly from the baseline assessment, there was a much greater association between knowledge and practice at that time.

A number of studies have highlighted that nurses now fully acknowledge the importance of research (McSherry, 1997; Dunn *et al.*, 1998). However, as this study has demonstrated, some are reluctant to base their care on empirical evidence (Closs & Cheater, 1994). Various conceptual frameworks have been put forward as a means of getting research into practice (Kitson *et al.*, 1996; Taylor-Piliae, 1998). Empirical findings may be translated into clinical guidelines based on research evidence (Bret, 1989; Coyle & Sokop, 1990; Duff *et al.*, 1996; Rutledge *et al.*, 1996). We intend to implement and evaluate such guidelines on endotracheal suctioning as part of our ongoing research programme.

One of the main limitations of this study relates to its small sample size. Indeed, the statistical significance of the findings cannot be precisely interpreted with these small numbers. However, the study was intended as a pilot study for a future investigation on a larger scale. Nevertheless, in spite of its limitations, the consistency of the findings provides confidence that these may be representative of this area of practice.

Conclusion and implications for nursing practice

The findings raised concerns about all aspects of endotracheal suctioning. A considerable lack of knowledge about various aspects of the suctioning procedure accompanied by poor practice was highlighted at the baseline assessment. However, it was encouraging to note that the experimental group showed considerable improvements in their knowledge and practice after teaching. These improvements were generally sustained, and provided evidence of the effectiveness of the educational intervention. Nevertheless, many subjects in the experimental group still believed that it was acceptable to use normal saline instillation prior to suctioning, in spite of an awareness of the empirical evidence and potential complications. This is a cause for concern because it is not in accordance with either the Scope of Professional Practice or Principles of Clinical Governance, which places a duty of responsibility on all health care professionals to ensure that care is satisfactory, consistent and evidence-based (NHSE, 1996a; Wilson, 1998).

This study has made some progress in establishing the current status of nurse's knowledge and practice of endotracheal suctioning, and is able to provide a framework for developing clinical guidelines for future practice. The main recommendation is for research-based guidelines to be introduced. It is recommended that every nurse, irrespective of length of intensive care unit experience or qualifications, should receive appropriate teaching to support these guidelines.

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APPENDIX 2:

Tracheal suctioning: an exploration of nurses' knowledge and competence in acute and high dependency ward areas

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Tracheal suctioning: an exploration of nurses' knowledge and competence in acute and high dependency ward areas

Background and rationale. With an increasing demand for intensive care beds more nurses in acute and high dependency wards will be expected to care competently for patients with tracheostomy tubes. Tracheal suctioning is an essential aspect of effective airway management. However, this has many associated risks and complications, ranging from trauma and hypoxaemia to, in extreme cases, cardiac arrest and death. It is imperative that nurses are aware of these risks and are able to practice according to current research recommendations.

Aims. This study was designed to explore nurses' knowledge and competence in performing tracheal suctioning in acute and high dependency ward areas and to investigate discrepancies between knowledge and practice using method triangulation.

Methods. Twenty-eight nurses were observed using nonparticipant observation and a structured observation schedule. Each subject was interviewed and questioned about their tracheal suctioning practices, and subsequently completed a knowledge-based questionnaire. Scores were allocated for knowledge and practice.

Findings. The findings demonstrated a poor level of knowledge for many subjects. This was also reflected in practice, as suctioning was performed against many of the research recommendations. Many nurses were unaware of recommended practice and a number demonstrated potentially unsafe practice. In addition, there was no significant relationship between knowledge and practice. However, during the

interviews, many nurses were able to provide a rationale for specific aspects of practice that were perhaps not based on current research recommendations.
Conclusions. The study raised concern about all aspects of tracheal suctioning and has highlighted the need for changes in practice, clinical guidelines and focused practice-based education.

Keywords: tracheal suctioning, knowledge, practice, evidence based practice, acute and high dependency, intensive care, tracheostomy

Introduction

As demands for intensive care beds increase more nurses in acute and high dependency ward areas will be expected to provide safe care for patients with tracheostomy tubes. The Audit Commission (1999) suggested that general ward nurses (other than specialists) should be able to care for patients with tracheostomy tubes as long as they have no other respiratory problems. However, there is evidence that practitioners are not adequately educated or experienced to care for patients with tracheostomy tubes in general wards (Tanser *et al.* 1997, Audit Commission 1999, Heafield *et al.* 1999). These findings not only have serious legal implications [United Kingdom Central Council for Nursing, Midwifery and Health Visiting (UKCC) 1992] but they hamper the intent of Comprehensive Critical Care [Department of Health (DoH) 2000], which aims to prevent readmission to ICU, facilitate discharge and share critical care skills. With the introduction of clinical governance, it is imperative that National Health Service (NHS) Trusts do all they can to improve the quality of their services and safeguard high standards of care by creating an environment in which excellence in clinical care can flourish (DoH 1998).

Review of the literature

The management of a tracheostomy tube is associated with several complications and risks. Tracheal suctioning, which is an essential aspect of airway management (Wainwright & Gould 1996, Wood 1998), has been identified as a potentially dangerous procedure which can lead to hypoxaemia (Adlkofer & Powaser 1978), cardiac dysrhythmias (Stone *et al.* 1991), trauma and atelectasis (Czarnik *et al.* 1991, Buglass 1999) and, in extreme cases, death (Marx *et al.* 1968). Other associated risks and complications include infection, bleeding, pain and tracheostomy tubes becoming blocked or displaced (Fiorentini 1992, Hackeling *et al.* 1998, Kapadia *et al.* 2000). In view of such hazards it is imperative that nurses are familiar with current research recommendations on all aspects of tracheal suctioning (Day 2000). Recommended practice is summarized in Table 1.

Despite the potential hazards associated with suctioning little empirical evidence exists of how well it is performed. Day *et al.* (2001) investigated the endotracheal suctioning practices of 16 intensive care nurses using nonparticipant observation and a knowledge-based questionnaire. The findings suggest that knowledge and practice were poor, with no significant relationship between the two. Similarly Celik and Elbas (2000) identified that current endotracheal suctioning practices within cardiac intensive care were not based on current recommended practice. Although no previous researchers have investigated actual suctioning practices of general ward nurses, studies (Tanser *et al.* 1997, Heafield *et al.* 1999) have explored nurses' knowledge and identified a need for further education and training.

The study

Aims

The principle aims of the study were:
- to evaluate nurses' theoretical knowledge and competence in performing tracheal suctioning in acute and high dependency wards;
- to investigate discrepancies between knowledge and practice using method triangulation (observation, interview and questionnaire).

Method

Design
This was a descriptive study producing quantitative and qualitative data to investigate knowledge and observed practice in the actual suctioning of patients. The study was designed to enable comparison of self-report and observation. The methods used consisted of nonparticipant observation, a knowledge-based questionnaire and audiotaped semi-struc-

Table 1 Summary of recommended practice

Action	Recommended practice
Assessment	In order to determine the need for suctioning and the effectiveness of the suctioning procedure, a thorough assessment of the patient should be made. This should include chest auscultation before and after suctioning (Glass & Grap 1995, Day 2000)
Patient preparation	Suctioning has been identified as a 'frightening and unpleasant experience' for patients (Griggs 1998) leading to anxiety, which has been shown to increase pain and discomfort (Fiorentini 1992). Therefore reassurance and explanation should always be given before and after suctioning
Preoxygenation	Suctioning may frequently lead to hypoxaemia (Adlkofer & Powaser 1978), which can cause cardiac dysrhythmias (Stone *et al.* 1991), hypotension (Goodnough 1985) and even cardiac arrest and death (Marx *et al.* 1968). In order to prevent these complications preoxygenation is recommended prior to suctioning (Wainwright & Gould 1996). Oxygen should be reduced to baseline levels postsuctioning (Day 2000) to prevent oxygen toxicity (Pierce 1995)
Infection control	Suctioning is an invasive procedure associated with an increased risk of infection (Pierce 1995). It is recommended that hands should be washed before and after suctioning and that aprons gloves and goggles should be worn during suctioning (Wood 1998, Parker 1999a, 1999b, Pratt *et al.* 2001)
Catheter selection	The external diameter of the suction catheter should not exceed one-half of the internal diameter of the tube (Odell *et al.* 1993, Glass & Grap 1995, Wood 1998). Larger catheters have been shown to cause trauma (Young 1984) whereas smaller catheter may be ineffective at removing secretions. The recommended formula to calculate the maximum size suction catheter to use is: size of endotracheal/tracheostomy tube $- 2 \times 2$ (Odell *et al.* 1993)
Negative pressure	Applied negative pressure should be between 80 and 150 mmHg or 10·6–20 kPa (Boggs 1993, Luce *et al.* 1993) as higher pressures have been shown to cause trauma, hypoxaemia and atelectasis (Czarnik *et al.* 1991). To prevent the catheter from adhering to the tracheal mucosa negative pressure should only be applied during withdrawal (Gibson 1983, DeCarle 1985, Allen 1988), and suction pressure should be applied continuously as opposed to intermittently (Glass & Grap 1995)
Duration of suction	It is recommended that the suctioning procedure should take between 10 and 15 seconds, as a longer duration has been associated with an increased risk of hypoxaemia and trauma (Allen 1988, Boggs 1993)
Number of suction passes	The number of suction passes may contribute to the occurrence of complications (Wood 1998). It is therefore recommended that no more than three suction passes be made during any one suction episode (Glass & Grap 1995)
Reconnect to oxygen therapy	In order to minimize the risk of hypoxaemia it is important to reconnect the patient to oxygen within 10 seconds postsuctioning (Adam & Osborne 1997, Day 2000)

tured interviews. The subjects were observed performing tracheal suctioning and then interviewed to explore their reasons for some of these actions. Finally the subjects were asked to complete a knowledge-based questionnaire in the presence of the researcher, to prevent potential contamination.

Sample

A consecutive sample of 28 subjects was recruited from three acute and high dependency ward areas in a large teaching hospital in south-east England. These wards were selected as they cared regularly for patients with tracheostomy tubes. Nurses were originally selected randomly from the off duty rota and invited to take part in the research. However, as a result of recruitment problems (staff shortages, sickness, subject refusal and lack of suitable patients) in the end, a convenience sample was obtained. This resulted in an unequal number of nurses being recruited from each ward and grade. Demographic data are presented in Table 2.

The majority of subjects were female ($n = 22$), six were male. Many subjects ($n = 26$) reported having previous experience of nursing patients with tracheostomy tubes and 12 indicated that they had completed a relevant postregistration course (acute, high dependency or critical care).

Research instruments

To enable direct comparisons to be drawn between knowledge and practice the observation and questionnaire instruments developed by Day *et al.* (2001) were designed in a similar format. These instruments were adapted for the purpose of this study as the focus of their research was endotracheal as opposed to tracheal suctioning. Minor modifications were made to take account of these factors. Each subject was observed performing tracheal suctioning on two occasions. Subjects were asked to suction at an appropriate time for the patient and in the normal way. Under no circumstances was suctioning undertaken solely for the purpose of the research. Nonparticipant observation may help to overcome discrepancies between what people say and what they actually do (Mays & Pope 1995). This method was therefore adopted to identify whether nurses demonstrate a level of knowledge that is also reflected in practice. Each subject was given a participant information sheet, which gave general information about the topic under investigation. The information was purposefully vague in order to gain an accurate reflection of practice and to minimize the Hawthorne effect. A semi-structured interview schedule based on previous work undertaken by King (1998) was then used to question the subjects about their tracheal suctioning practices. Finally the subjects were asked to complete a knowledge-based questionnaire. This multi-method triangulation approach was used as it might explain discrepancies between knowledge and practice (Norman *et al.* 1992). Triangulation, as described by Norman *et al.* (1992), involves the use of more than one research strategy in an attempt to reveal the various dimensions of the domain of interest.

Validity and reliability

During the pilot study ($n = 6$), the observation schedule was tested for inter-rater reliability using a second observer (Cohen 1968) and again midway through the study ($n = 3$) to test for observer drift. Although per cent agreements are easy to calculate, they fail to allow for chance agreements or commission vs. omission errors (Topf 1986). Kappa measurements were therefore calculated, which have the advantage of controlling for chance agreements (LeMay 1992). During the pilot study percentage agreements ranged from 80% to 100% and kappa measurements from 0·64 to 1·0, indicating a good level of agreement (Brennan & Silman 1992). Midway through the study percentage agreements ranged from 77·8% to 100% and kappa measurements from 0·67 to 1·0 suggesting that observer drift did not occur.

Ethical approval

Each participant was given an information sheet, which outlined the research and what was expected of him or her if they agreed to participate in the study. Written consent was obtained from all participants. Ethical approval was obtained from the School of Nursing Research Ethics Committee.

Pilot study

The pilot study commenced once ethical approval had been obtained. A total of six nurses (20%) were recruited from two of the wards. No subsequent modifications to the research instruments were deemed necessary.

Coding and scoring

The subjects were assessed against 20 different categories relating to tracheal suctioning and given a score out of 20 for both knowledge and practice. One mark was given for a correct response or action and no mark given for an incorrect response or action.

Data analysis

Inferential and descriptive statistics were used. The descriptive statistics included frequency ratings and percentages for nominal level data. The inferential statistics included the use of nonparametric statistical tests (Mann–Whitney, Kruskal–Wallis test and Spearman's rho correlation coefficient). A significance level of $P < 0.05$ was accepted as statistically significant.

Results

The results are divided into three sections, prior to suctioning, during suctioning and postsuctioning. Each will be addressed in turn. Initially the descriptive statistics will be addressed, followed by the inferential statistics.

Table 2 Demographic data

Grades and number of subjects		Wards and number of subjects		Age range and number of subjects		Postregistration experience (years) and number of subjects	
				20–24	5	<1	2
D	11	One	11	25–29	9	1–2	6
E	11	Two	9	30–34	7	2–5	9
F	5	Three	8	35–39	1	5–10	7
G	1			>39	6	>10	4

Table 3 Prior to suctioning: knowledge and practice responses for each scored category

Category	Knowledge ($n = 28$)	%	Practice ($n = 28$)	%
Prior to suctioning				
(1) Auscultation	19	67·9	2	7·1
Incorrect: No auscultation	9	32·1	26	92·9
(2) Patient preparation	25	89·3	20	71·4
Incorrect: No preparation	3	10·7	8	28·6
(3) Preoxygenation	10	35·7	2	7·1
Incorrect: No preoxygenation	18	64·3	26	92·9
(4) Avoidance of saline	1	3·6	28	100
Incorrect: Would/did use saline	27	96·4	0	0
Infection control measures				
(5) Hand washing before (general*)	5	17·9	2	7·1
	2*	7·1*	N/A	N/A
Incorrect: No hand washing before	21	75·0	26	92·9
(6) Use of gloves	23	82·1	28	100
Incorrect: No gloves	5	17·9	0	0
(7) Use of aprons	10	35·7	21	75
Incorrect: No aprons	18	64·3	7	25
(8) Use of goggles	10	35·7	10	35·7
Incorrect: No goggles	18	64·3	18	64·3

*Indicated hand washing in general, did not specify before or after; N/A: Not applicable.

Descriptive statistics

Prior to suctioning

Overall, some subjects knowledge and practice prior to suctioning did not appear to be based on current research recommendations. There also appeared to be little relationship between knowledge and practice (see Table 3). For example, the majority of subjects ($n = 19$) indicated correctly that suctioning should only be performed following chest auscultation. However, only two subjects were observed performing auscultation in practice.

Despite many ($n = 23$) subjects being aware of possible complications associated with normal saline instillation nearly all ($n = 27$) suggested that they would use it. Only one indicated that they would not use it at all. Twelve subjects suggested using 1 or 2 mL, four suggested 3 or 4 mL and 11 subjects suggested using 5 or >5 mL. However, no subjects were observed to actually use normal saline in practice.

Suctioning

Some subjects' knowledge and practice during suctioning was not based on current research recommendations. Furthermore, there appeared to be little correlation between knowledge and practice, as presented in Table 4.

In relation to catheter selection, subjects indicated several different methods for calculating an appropriate size. Only seven subjects indicated an appropriate method: minus 2 multiply by 2 (Odell *et al.* 1993), catheter should not exceed one-half the internal diameter of the tube (Odell *et al.* 1993, Glass & Grap 1995, Wood 1998) and multiply by 2 minus 4. From the remaining responses, many subjects did not know how to calculate catheter size accurately. For example one subject suggested, 'the larger the tracheostomy, the bigger the catheter.'

Postsuctioning

Subjects' postsuctioning knowledge and practice were also not based on current research recommendations. There also appeared to be little relationship between knowledge and practice, as presented in Table 5.

Knowledge and practice scores

Throughout the study, the majority of subjects ($n = 14$) failed to perform the suctioning procedure as accurately as they had reported. None of the subjects obtained complete accuracy for all components of tracheal suctioning. The maximum possible score was 20 points and actual scores ranged from four to 16 for knowledge, and seven to 14 and a half for practice. The mean score for knowledge was 11·1 and 10·3 for practice.

The scores have been categorized into four groups (0–5, >5–10, >10–15 and >15–20), as presented in Figure 1.

Table 4 Suctioning: knowledge and practice responses for each scored category

Category	Knowledge ($n = 28$)	%	Practice ($n = 28$)	%
Suctioning				
(9) Accurate catheter size	18	64·3	9	32·1
Incorrect size				
Smaller catheter	5	17·9	1	3·6
Larger catheter	3	10·7	18	64·3
Selected > one catheter	2	7·1	0	0
(10) Accurate suction pressure (80–150 mmHg, 10·6–20 kPa)	10	35·7	2	7·1
Incorrect pressure				
<50 mmHg (<6·6 kPa)	7	25	0	0
50–79 mmHg (6·6–10·5 kPa)	3	10·7	0	0
150–199 mmHg (20–26·5 kPa)	6	21·4	13	46·4
>200 mmHg (26·5 kPa)	0	0	13	46·4
Unsure	2	7·1	0	0
(11) Correct application of pressure (withdrawal)	27	96·4	27	96·4
Incorrect application				
On insertion	1	3·6	0	0
Insertion and withdrawal	0	0	1	3·6
(12) Continuous pressure	21	75	25	89·3
Incorrect pressure				
Intermittent	4	14·3	3	10·7
Either	2	7·1	0	0
Unsure	1	3·6	N/A	N/A
(13) Correct withdrawal (no lateral movement)	15	53·6	18	64·3
Incorrect withdrawal				
Rotation	9	32·1	8	28·6
Twisting	1	3·6	0	0
Upward/downward movement	1	3·6	2	7·1
Unsure	2	7·1	N/A	N/A
(14) Accurate duration (10–15 seconds)	10	35·7	12	42·9
Incorrect duration				
5–9 seconds	15	53·6	6	21·4
16–20 seconds	2	7·1	4	14·3
21–25 seconds	0	0	0	0
>25 seconds	0	0	2	7·1
Unsure/inconsistent	1	3·6	4	14·3
(15) Correct number of suction passes (1–3)	26	92·9	27	96·4
Incorrect				
>3 passes	1	3·6	1	3·6
Unsure	1	3·6	N/A	N/A

Only 15 subjects (53·5%) attained a score of more than 10 for knowledge and 13 (46·4%) scored more than 10 for practice.

Inferential statistics

Knowledge and practice scores were compared using Spearman's ρ correlation coefficient. Although a weak correlation was identified ($r = 0.338$) this was not statistically significant ($P > 0.05$). There was no significant relationship between knowledge and practice scores.

Ward area

The knowledge and practice scores of the three ward areas were compared using Kruskal–Wallis. A significant difference was identified with ward one demonstrating higher scores than wards two and three ($P < 0.05$).

Table 5 Postsuctioning: knowledge and practice responses for each scored category

Category	Knowledge (n = 28)	%	Practice (n = 28)	%
Postsuctioning				
(16) Chest auscultation	22	78·6	1	3·6
Incorrect: No chest auscultation	6	21·4	27	96·4
(17) Reconnection of oxygen within 10 seconds	23	82·1	16	57·1
Incorrect length of reconnection				
Within 30 seconds	4	14·2	8	28·6
Inconsistent	N/A	N/A	2	7·1
No response	1	3·6	0	0
N/A – Patient self-ventilating on air	N/A	N/A	2	7·1
(18) Decreased oxygen to previous setting	12	42·9	2	7·1
Incorrect				
No decreased oxygen	16	57·1	24	85·7
N/A – Patient self-ventilating on air	N/A	N/A	2	7·1
(19) Patient reassurance	16	57·1	14	50·0
Incorrect: no patient reassurance given	12	42·9	14	50·0
Infection control measures				
(20) Hand washing after	4	14·3	17	60·7
Incorrect: No hand washing after	24	85·7	11	39·3

Grades

The observation scores for D grade subjects were significantly lower than other grades. This was statistically significant for practice ($P < 0.05$) although not for knowledge ($P > 0.05$).

Postregistration experience

No statistically significant differences were identified between postregistration experience (years qualified) and knowledge and practice scores ($P > 0.05$).

Postregistration courses

Those subjects who had completed a relevant postregistration course (acute, high dependency, critical care course) had significant higher scores. This was statistically significant for the knowledge ($P < 0.05$) and practice scores ($P < 0.01$).

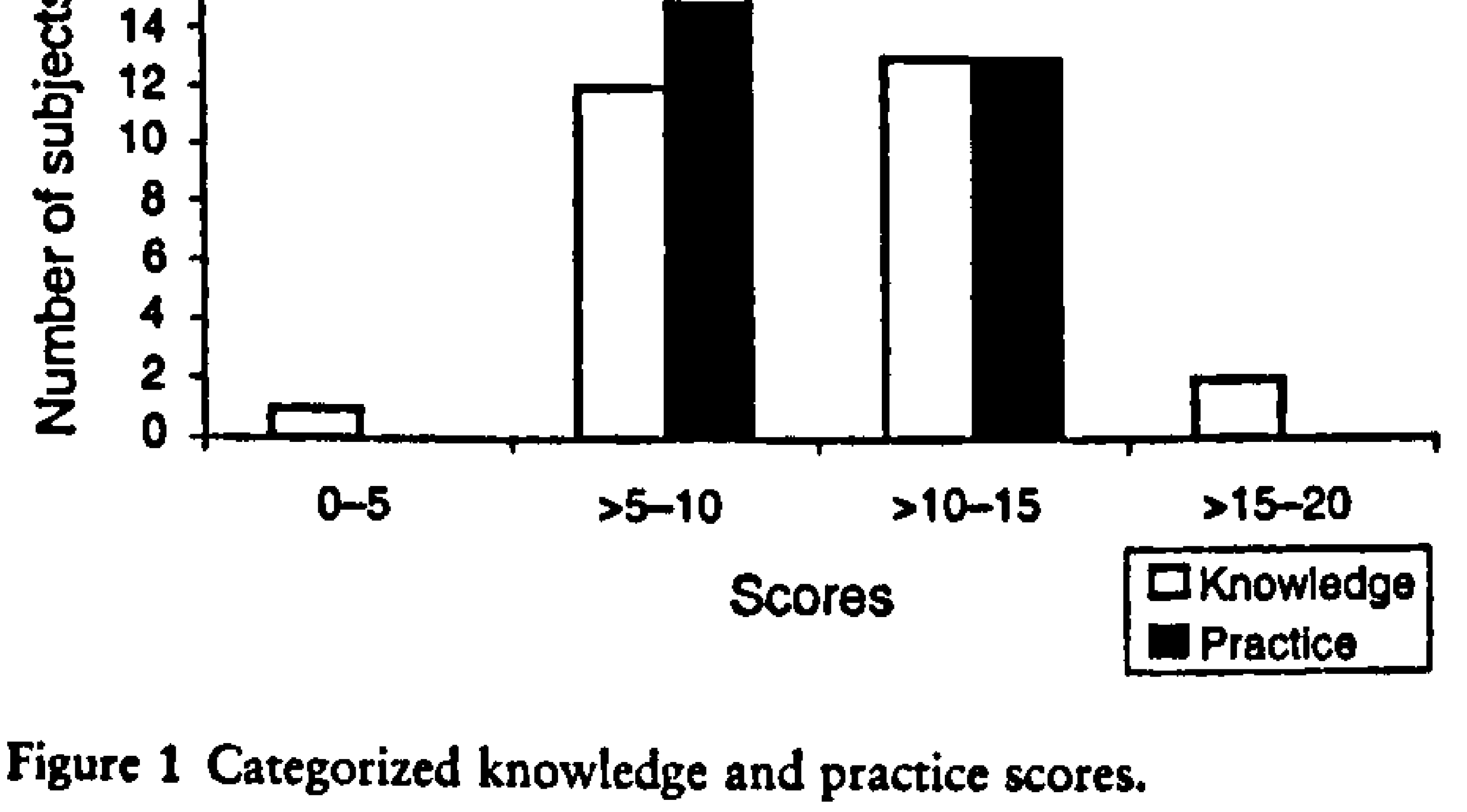

Figure 1 Categorized knowledge and practice scores.

Gender and age

There were no statistically significant differences between gender, age and scores ($P > 0.05$).

Discussion

The findings from this study raised some interesting issues relating to all aspects of tracheal suctioning. The two methods employed to examine nurses' knowledge and practice were successful in generating information that was comparable and amenable to statistical analysis. In addition, the interviews provided valuable contextual information to explain the discrepancies between knowledge and practice.

The aims of this study were to evaluate nurses' theoretical knowledge and competence in performing tracheal suctioning in acute and high dependency ward areas and to investigate discrepancies between knowledge and practice using method triangulation. The findings are of great concern as many nurses failed to demonstrate an acceptable level of competence for knowledge and practice. Many nurses were unaware of recommended practice and some demonstrated potentially unsafe practice. These findings support previous research findings (Celik & Elbas 2000, Day *et al.* 2001). The findings also indicate that there was no significant relationship between nurses' theoretical knowledge and observed practice. Several other studies have also reported a lack of association between nurses' knowledge and practice (Gould *et al.* 1996, Day *et al.* 2001).

The findings suggest that postregistration courses may have a direct influence on subject scores. Many ($n = 9$) of the 12 subjects who had undertaken a relevant course were from ward one, which may account for why ward one had significantly higher scores. The findings also indicate that subject scores were influenced by grade, with junior nurses scoring less than senior nurses. However, this was only statistically significant for practice. One possible explanation would be that junior nurses had less practical experience in caring for patients with tracheostomies. However, overall the findings suggest that there was no significant correlation between length of postregistration experience and knowledge or practice scores.

Prior to suctioning

To determine the need for tracheal suctioning it is recommended that a thorough assessment of the patient should be made prior to suctioning, which should include chest auscultation (Glass & Grap 1995, Day 2000). Although many subjects ($n = 19$) identified that course breath sounds on auscultation would influence their decision to suction, only two were observed performing chest auscultation in practice. However, from the interviews it was apparent that many nurses assess their patients without the aid of a stethoscope, as subjects spoke of 'listening' to chest sounds and 'hearing' the secretions. One subject said, 'I felt her chest and I could feel a bit of gurgling'.

Informing the patient and encouraging their participation has been identified as a strategy for relieving distress and anxiety and for maximizing the effectiveness of suctioning (Demers & Saklad 1973, Fiorentini 1992). Many ($n = 25$) subjects identified that patients should be given reassurance prior to suctioning and in practice 20 subjects were observed giving adequate reassurance. However, in the interview situation some subjects gave a rationale for why they had not prepared the patient by suggesting that, 'the patient had asked to be suctioned'. Others felt that the patient was aware of the procedure, 'He's had it done a few times now so he knows what to expect but the first time you need to explain to them what's gonna happen and how it's gonna feel'.

Actions recommended to minimize the risk of hypoxaemia prior to suctioning include preoxygenation or hyper-oxygenation (Wainwright & Gould 1996). Although, 10 subjects recommended preoxygenation in the questionnaire, only two were observed in practice. Some patients were being encouraged to take deep breaths prior to tracheal suctioning, which could potentially reduce hypoxaemia. One subject in the interview said, 'I don't routinely preoxygenate unless I've got some reason to believe that patients may be at particular risk of desaturating'. Although this may account for why some subjects did not preoxygenate, it does not account for the general lack of knowledge with regards to preventing hypoxaemia. However, as much of the research (Adlkofer & Powaser 1978, Mancinelli-Van Atta & Beck 1992) advocating the use of preoxygenation focuses on critically ill patients in intensive care, it could be argued that further research work into acutely ill patients on general wards is required to support the use of preoxygenation.

Although there has been much confusion surrounding normal saline instillation there is no evidence to date to suggest that this practice is beneficial. However, there is an increasing amount to suggest that this practice may be harmful (Demers & Saklad 1973, Hanley *et al.* 1978, Rutala *et al.* 1984, Ackerman & Gugerty 1990, Blackwood 1999, Kinloch & Rock 1999). It was encouraging to note that none of the subjects were observed using normal saline in practice. Despite most subjects ($n = 23$) being aware of the associated complications surrounding the use of normal saline, 27 believed that it was acceptable to instil prior to suctioning, with 11 subjects recommending 5 mL or more, yet normal saline instillation is not recommended practice (Blackwood 1999, Kinloch & Rock 1999).

Suctioning is an invasive procedure associated with an increased risk of infection (Pierce 1995). Recommended actions include hand wash before and after suctioning and wearing gloves, goggles and aprons (Wood 1998, Pratt *et al.* 2001). Only two subjects were observed washing their hands prior to suctioning, yet the literature suggests that gloves do not replace the need for hand washing (Parker 1999a, Pratt *et al.* 2001). Although all ($n = 28$) subjects wore gloves and most wore aprons ($n = 21$) few were observed wearing goggles ($n = 10$). These findings suggest that nurses demonstrate a lack of compliance with universal infection control precautions.

Suctioning

The external diameter of the suction catheter should not exceed one-half of the internal diameter of the tube (Odell *et al.* 1993, Glass & Grap 1995, Wood 1998). Few ($n = 9$) subjects were observed using an appropriate size suction catheter with most ($n = 18$) using a catheter that was too large. Larger catheters have been associated with trauma (Young 1984) and hypoxaemia (Odell *et al.* 1993). Some subjects gave a rationale for their actions by highlighting that the ward had a lack of small suction catheters or that the patient had thick secretions. A more likely explanation, however, was that subjects did not know how to calculate which suction catheter to use, as few subjects ($n = 7$) indicated an appropriate method.

It is recommended that negative pressure should be between 80 and 150 mmHg (Boggs 1993, Luce *et al.* 1993). Few ($n = 2$) subjects were observed following this recommended practice with most ($n = 26$) using pressures of 150 to >200 mmHg. Five were observed, on different occasions, using suction pressures of 263–300 mmHg, which is twice the recommended pressure. Such high pressures have been associated with mucosal damage, trauma and atelectasis (Czarnik *et al.* 1991, Boggs 1993, Luce *et al.* 1993, Buglass 1999). Buglass (1999) suggests that higher pressures may be a consequence of a lack of knowledge or carelessness in not checking the pressure gauge, or a belief that more secretions will be removed with stronger suction. It is apparent from this study that subjects failed to distinguish between 'set' and 'applied' negative pressures. On several occasions 'set' suction pressures of 150 mmHg were observed. During the suctioning procedure the actual 'applied' pressure increased to as much as 188 mmHg, exceeding the recommended negative pressure.

Most ($n = 27$) subjects followed recommended practice and applied suction pressure during withdrawal of the suction catheter (Gibson 1983, DeCarle 1985, Allen 1988) and many ($n = 25$) used continuous pressure (Glass & Grap 1995). Only 18 subjects were observed withdrawing the suction catheter in the recommended manner, with no lateral movement. Of the remaining subjects eight used a rotational method, which may contribute to further trauma (Glass & Grap 1995).

Few ($n = 10$) subjects were aware of the recommended duration for suctioning (10–15 seconds), and only 12 subjects were observed suctioning according to this timeframe. Of the remaining subjects, six performed tracheal suctioning in less than the recommended duration, six more than the recommended duration, and four were inconsistent in their approach. A longer duration is associated with an increased risk of hypoxaemia and trauma (Allen 1988, Boggs 1993, Odell *et al.* 1993) and suctioning too quickly may be ineffective at clearing all secretions. However, it is important to remove secretions adequately.

It is recommended that no more than three suction passes be made during any suctioning episode (Glass & Grap 1995) because the number of suction passes are thought to contribute to the occurrence of complications (Wood 1998). Only one subject failed to follow this recommended practice.

Postsuctioning

In order to evaluate the effectiveness of the suctioning it is recommended that a comprehensive respiratory assessment takes place following suctioning (Glass & Grap 1995). This should include chest auscultation to assess air entry and breath sounds (Day 2000). Although most ($n = 22$) subjects indicated that they would listen to chest sounds after suctioning, only one subject was observed to perform this in practice. Many of the subjects spoke of 'listening' to secretions and commented that secretions could not be heard, which indicates that they did in fact make an assessment of the patient.

In order to reduce the risk of hypoxaemia, it is recommended that oxygen therapy be reconnected to the patient as soon as possible after suctioning, preferably within 10 seconds (Adam & Osborne 1997, Day 2000). Only 16 subjects followed this recommended practice. Of the remaining subjects, all eventually reconnected the oxygen within 30 seconds. Although time is difficult to estimate and measure, the importance of reconnecting the patient to oxygen therapy within the minimum time delay cannot be over emphasized. After suctioning, the percentage of inspired oxygen should always be reduced to that of the baseline level (Day 2000) to prevent oxygen toxicity (Pierce 1995). All subjects ($n = 2$) who had previously preoxygenated their patient followed this recommended practice. It is important that verbal reassurance is given to the patient both before and after suctioning. Only 14 subjects offered reassurance post-suctioning. This is of concern, as suctioning has been described as 'frightening and unpleasant experience for patients' (Griggs 1998). In order to prevent cross-infection, it is imperative that hand washing occurs after suctioning (Parker 1999b). Only 17 subjects were observed washing their hands postsuctioning.

The findings of this study are similar to the original study of Day *et al.* (2001) and highlight a need for education and training relating to tracheal suctioning. What is especially worrying is the level of discrepancy between knowledge and practice in spite of the Hawthorne effect, which is a well documented limitation of observational research (Endacott 1994). This factor alone makes the differences noted even more significant.

It was apparent from the interviews that many subjects expressed concern about their own suctioning practices and felt generally unsupported. One subject said, 'I think we should have more instruction really, basically you end up looking out for the instruction rather than it being provided.' Another subjects said, 'I don't remember getting any good teaching so I think in some ways I've taught myself and also I've sort of been quite scared in situations.' One other subjects said, 'I don't really feel very confident when it comes to suctioning but I do try my best.' In order to facilitate effective decision-making and improve standards of care it is vital that nurses receive adequate education and training related to tracheal suctioning based on research evidence.

It should be acknowledged that occasionally it might be acceptable not to follow research recommendations strictly. For example if thick sputum cannot be removed from a patient's airway then it may be necessary to use a larger suction catheter and/or increase the suction pressure on that occasion. However, after the event measures should be taken to prevent this incident occurring again, such as providing adequate humidification and systematically hydrating the patient (Ackerman 1993, Blackwood 1999).

Study limitations

The main limitations of this study relate to the small sample size and that it was confined to one institution only. The findings might not therefore be representative of the general population of nurses. A further limitation was that the scores were not weighted, and some items may have contributed to the overall scores more than others. As subjects were only observed suctioning on two occasions, it could be argued that this does not provide a true representation of suctioning practices as a whole. However, as only a few inconsistencies were noted, this was felt to be unlikely. It is also acknowledged that some contamination may have occurred as subjects may have spoken to colleagues about the research. However, this was not evident from the scores.

Conclusion

With the introduction of clinical governance it is imperative that NHS Trusts do all they can to improve the quality of their services and safeguard high standards of care by creating an environment in which excellence in clinical care can flourish (DOH 1998). It is essential that all nurses are aware of recommended practice because undertaking practices which are not evidence based is not in accordance with the Scope of Professional Practice (UKCC 1992).

Despite the small sample, this study has identified that nurses require support, education and training relating to tracheal suctioning. These findings are supported by several other authors (Tanser *et al.* 1997, Heafield *et al.* 1999, Celik & Elbas 2000, Day *et al.* 2001). A study incorporating a teaching intervention is therefore recommended to improve nurses' knowledge and competence in the care of patients requiring tracheal suctioning. It is also recommended that clinical guidelines are in place. However, these guidelines should incorporate a degree of flexibility, wherever possible. This will enable practitioners to base their practice on sound clinical judgement, as well as empirical evidence.

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NHS

APPENDIX 3: ETHICAL APPROVAL
Specimen 1: Original letter from Ethics Committee

Our Ref: AJ/PM

Tina Day
Lecturer in Critical Care
Florence Nightingale School of Nursing
& Midwifery
King's College London
James Clerk Maxwell Building
Waterloo Road
London SE1 8WA

28th October 2003

Dear Ms Day,

Protocol: An evaluation of multifaceted educational interventions to improve the practice of tracheal suctioning amongst health care professionals

LREC Ref No: 03/09/02 *(please quote in all correspondence)*

Thank you for your e.mail of 20th October 2003 responding to the points raised by the committee. I am pleased to advise you that the chair has approved all the amendments made and that your study has now been fully approved on the understanding that you will follow the protocol as agreed. It is the responsibility of the lead researcher to notify the REC immediately if you become aware of anything which casts doubt upon the conduct, safety or an unintended outcome of the study for which approval was given.

If there are amendments, which in the opinion of you or your colleagues could radically alter the nature of the approved study, a revised protocol should be submitted.

The Committee expects that research records are kept secure and accessible for a minimum period of 10 years and that a report is submitted annually or a copy of the results are sent upon completion of the study.

Important note: Ethical approval does not give you permission to carry out the work in the S Trust. This must be confirmed with the R&D Department who can be contacted on

REC works in accordance with ICH Good Clinical Practice.

Yours sincerely,

pp Annette Jeanes

Specimen 2: Approval for modifications to protocol on main study site

Date: Tue, 04 Jan 2005 09:34:05 +0000
From: Pat Martin <Pat.Martin@uhl.nhs.uk>
Subject: Re: Tracheal suctioning project
To: tina.day@kcl.ac.uk
Message-ID: <s1da6321.047@imt8d.uhl.nhs.uk>

Hi Tina

Not sure whether Annette Jeanes replied to you - so am letting you know that this is fine with her.

Pat

>>> Tina Day <tina.day@kcl.ac.uk> 16/12/04 12:44:52 >>>
Dear Pat

We have had to make an ammendment to the tracheal suctioning project and will need to run this past Annette Jeanes, as Chair of the Ethics Committee. There have been very few patients with tracheostomies

at his past year (hence the need to extend the project to
nd as a result we have decided to observe the nurses and physiotherapist using a mannequin simulation instead of in the practice setting. There should be no further ethical issues associated with this as we will no longer be involving patients. The design of the study otherwise remains unchanged.

Would you be able to pass this information on the Annette.

Many Thanks

Tina Day

Tina Day
tina.day@kcl.ac.uk

Pat Martin

Specimen 3: **Approval to extend the study to a second site**

Tina Day
Lecturer in Critical Care
Florence Nightingale School of Nursing
& Midwifery
King's College London
James Clerk Maxwell Building
Waterloo Road
London SE1 8WA

13th September 2004

Dear Ms Day,

Protocol: **An evaluation of multifaceted educational interventions to improve the practice of tracheal suctioning amongst health care professionals**

LREC Ref No: **03/09/02** (*please quote in all correspondence*)

Research Ethics Committee gave a favourable ethical opinion to this study on 28th October 2003.

Notification of no objection to the conduct of this research has been received from the local site assessor at Hospital following site-specific assessment.

Management approval

The Chief Investigator or sponsor should inform the principal investigator of the favourable opinion by sending a copy of this letter. The research should not commence until management approval from the relevant host organisation has been confirmed.

Statement of compliance (from 1 May 2004)

The committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

Yours sincerely,

pp Annette Jeane

Specimen 4: **Management approval**

NHS

Tina Day
Lecturer
Kings College London
Florence Nightingale School of Nursing & Midwifery
57 Waterloo Road
London SE1 8WA

Dear Tina,

Thank you for your letter of request regarding your proposal to conduct your research at

Please accept this letter as confirmation of our willingness and consent to support your Mphil/phD research being conducted at the proviso that Sue Waters Professional Lead Core Clinical Services is happy trom the AHP perspective.

We look forward to working with you throughout your research.

Yours sincerely,

CGeddes

Cathy Geddes
Acting Director of Nursing

c.c Sue Waters – Professional Lead Core Clinical Services

NHS

Tina Day
Lecturer
Kings College London
Florence Nightingale School of Nursing and Midwifery
57 Waterloo Road
London
SE1 8WA

5th August 2004

Dear Tina

Thank you for your letter of request and a copy of your proposal regarding conducting your research at

I have had the opportunity to discuss this with the Acting Director of Therapies and Head of Physiotherapy and we are willing to support this proposal.

We look forward to working with you throughout your research.

Yours sincerely

Sue Waters
Professional Lead Core Clinical Services

NHS

APPENDIX 4: RESEARCH AND DEVELOPMENT APPROVAL

Ms Tina Day,
Nightingale School of Nursing
James Clerk Maxwell Building
King's College London
57 Waterloo Road
London
SE1 8WA

Dear Ms Day,

ID: 650 An evaluation of a multifaceted educational intervention to improve the practice of tracheal suctioning amongst healthcare professionals

Thank you very much for registering your research with the R&D Unit. This has been reviewed in line with our guidelines and discussed with the relevant Manager for your area.

We need to remind you of the requirements of the Research Governance Framework. As part of the Research Governance Framework the Lead Trust Researcher for a project needs to ensure that both the R&D Unit and Ethics Committee are kept up to date with any changes to the project. As such it is your responsibility to inform us of the any changes to the following: start and finish dates, inclusion/exclusion criteria, recruitment processes, patient information sheets, funding/cost pressures, research team. You may also need to inform the LREC or MREC concerned with this project, please contact them separately.

Can I also remind you that under research governance it is your responsibility to report any adverse or health and safety events, that happen as a result of the study, to the R&D Unit. In addition you have contractual obligations with regard to this project which include the adherence to the all Trust policies but especially the following policies; Confidentiality Policy, Fraud and Corruption Policies, Data Protection Act and Health and Safety. It is also your responsibility as the Trust lead for this project to ensure that all staff involved with the project are adequately trained.

If you require any assistance, or have any updates on your project that you need to notify us of please contact Gill Lambert on ext 6873 or via e-mail. We will make contact with you on a regular basis to ensure that your project continues to meet these requirements. We will also contact you on completion of your project and would be interested to receive a brief summary of the outcomes and where you plan to publish your findings.

Yours sincerely

G. Lambert.

R. Dr Garbielle Kingsley
R&D Director
GK

Date: Tue, 26 Oct 2004 15:16:53 +0100
From: Jackie.Pullen@
Subject: Your research project has been registered!
To: tina.day@kcl.ac.uk
Message-ID: <436D1650543DD4118B1300508B6B82C10C772FDB@EX3>

Dear Tina

Re: "An evaluation of a multifaceted educational intervention to improve the practice of tracheal suctioning amongst healthcare professionals"

Thank you for submitting your research project to the R&D Department. The project has now been approved by the Trust and has been allocated the Trust R&D registration number RJ1 04/0255. The project has been registered on the Trust's research database. Please quote the R&D registration number in any communications with the R&D Department regarding your project.

Please be aware that this is conditional to all researchers holding honorary or substantive contracts with the Trust.
Trust approval for the research is subject to the research being undertaken in line with the Department of Health's Research Governance Framework, and Trust policies relating to Research Governance. The Research Governance Framework and details of you and your researchers responsibilities within this framework can be found on the Department of Health's website at:

<www.dh.gov.uk/policyandguidance/researchanddevelopment/researchanddevelopmentaz/researchgovernance/fs/en <http://www.dh.gov.uk/policyandguidance/researchanddevelopment/researchanddevelopmentaz/researchgovernance/fs/en>> or on the Trust's intranet at <<http://tww:8080/article.asp?typeid=1&articleID=2218>>.

Please ensure that you and your researchers are aware of your responsibilities under this Framework.

In line with the Research Governance Framework, your project may be randomly selected for monitoring for compliance against the standards set out in the Framework. For information, the Trust's process for the monitoring of projects and the associated guidance is available from the Trust's intranet or on request from the R&D Department. You will be notified by the R&D Department if and when your project has been selected as part of the monitoring process. No action is needed until that time.

Once the project has started I would be grateful if you can let me know the actual start date?

Kind Regards
Jackie

Jackie Pullen
Clinical Trials / Research Coordinator
Research & Development Office

APPENDIX 5: PARTICIPANT INFORMATION SHEET
(For nurses and physiotherapists involved in the study)

TITLE OF STUDY:
An evaluation of multifaceted educational interventions to improve the practice of tracheal suctioning amongst health care professionals.

Introduction
We are a research team based at the Florence Nightingale School of Nursing and Midwifery. We are undertaking a research study to explore nurses' and physiotherapist's knowledge and practice of tracheal suctioning. This sheet has been designed to give you information about the study and what would be expected of you if you agree to participate.

What the study is about
Tracheal suctioning is a crucial aspect of care for patients with tracheostomy tubes. This study will look at your knowledge, practice and decision-making in relation to all aspects of tracheal suctioning in acute and high dependency settings. The study will also involve an educational programme and looks at the effectiveness of teaching on knowledge and practice.

What we would like you to do
You have been randomly selected to take part in this study. If you agree to participate, we would like to observe you performing two suction passes. These observations will take place in your own practice setting, during your shift and at an appropriate time for your patient. You will be observed by one of two researchers and during the observations we will have a chart to record your practice. We will not participate in the procedure or answer any questions unless in the exceptional event of untoward practice when this would be discussed with the participant. After the observations, you will then be asked to compete a questionnaire. The questionnaire will take a maximum of 15 minutes to compete and a researcher will remain present throughout. However, we will be unable to answer any questions relating to tracheal suctioning. You will then receive an interactive seminar presentation, and be observed again shortly after this and again approximately three months later. If you are assigned to the experimental arm of this study, you will also receive reminders, audit and feedback about aspects of your practice prior to being observed again at the three-month period.

How long will you be involved?
The period of data collection is envisaged to take place over a period of 6 to 9 months.

Confidentiality
The information collected will be treated with compete confidentiality at all times. The observation sheets and questionnaires will be kept in a locked cupboard and will be kept for 10 years, after which they will be destroyed. Your names will not appear on any of the documentation and you will be given a confidential code known only to the researcher so that we can match your responses. You will be unable to be identified in the final report.

Refusal to participate/withdraw from the study
You are under no obligation to take part in this study. If you wish to withdraw from the study at any time, or do not wish to be observed on a particular occasion, you may do so without providing a reason.

Who has reviewed the study?
The Local research Ethics Committee has reviewed this study.

Contact for further information

Researcher name: Tina Day

Contact telephone number: XXXX (work)
XXXX (home)
XXXX (mobile)

The Research Ethics Committee has approved the above study, which requires written consent

Tina Day, Lecturer and Researcher--

Signed by the Chair of the Committee--

Date:---------------------------------- Proposal number: 03/09/02

APPENDIX 6: CONSENT FORM

FORM OF CONSENT

I...of...

Agree to participate in the research described above. The nature, purpose and possible consequences of the procedures involved have been explained to me by Mrs Tina Day and are acceptable to me.

I understand that I am entering this project of my own free will and am free to withdraw at any time, without necessarily giving any reason. In addition, my participation or non-participation in this project will in no way affect the care that is given to my patients.

Name:
(Please Print)

Signature: Date:

Witnessed by: Date:

APPENDIX 7: PATIENT INFORMATION SHEET

TITLE OF STUDY:

An evaluation of a range of educational programmes to improve the practice of tracheal suctioning amongst health care professionals

Introduction

We are a research team based at the Florence Nightingale School of Nursing and Midwifery. We are undertaking a research study to explore nurses' and physiotherapist's knowledge and practice of tracheal suctioning. This information sheet has been designed to give you information about the study.

What the study is about

Tracheal suctioning is a crucial aspect of care for patients with tracheostomy tubes. This study will look at nurses and physiotherapist's knowledge and practice of this procedure in acute and high dependency settings.

What we would like you to do

With your permission, we would like to observe your nurse and physiotherapist performing tracheal suctioning on two separate occasions. Suctioning will only be performed when it is deemed necessary and will not be undertaken purely for the purposes of this research study. This will in no way affect the care that you receive. I must emphasise that it is the nurses and physiotherapists that we are observing and not you as a patient.

How long will you be involved?

The study is envisaged to take place over a period of six to nine months. However the length of your involvement will depend on how long you have a tracheostomy tube in place. You may be involved in the study on more than one occasion during this time.

Confidentiality

Confidentiality will be maintained at all times.

Refusal to participate/withdraw from the study

You are under no obligation to take part in this study. If you do not want the researcher to observe the nurse or physiotherapist then you may refuse without giving a reason. Refusal to take part in this study will in no way effect the care that you receive.

Tina Day, Lecturer and Researcher

The Research Ethics Committee has approved the above study, which requires verbal consent from patients or their relatives
Signed by the Chair of the Committee______________________________

Date______________ **Proposal Number** **03/09/02**

APPENDIX 8: LITERATURE SEARCH STRATEGIES

Searching for the best available evidence means searching the most appropriate databases, assessing the quality of information and questioning whether this information should be accepted or rejected (McKibbon and Marks 1998).

1.1 Education for health care practice

The first literature search was undertaken using CINAHL, MEDLINE and Cochrane databases. Key words used during the second search included:

1. Adult education
2. Multifaceted education
3. Performance feedback
4. Simulation
5. Skills retention
6. Knowledge and skills
7. 1 and 2
8. 1 and 3

For multifaceted education, 27 papers were found. None related to tracheal suctioning or any other aspects of the suctioning procedure. However, many related to hand washing practice, which was felt to be a relevant clinical skill. Five papers discussed the use of reminders and 13 further studies related to performance feedback. For the purpose of the literature review, these studies were therefore reviewed as they were felt to be relevant. For knowledge and skills retention, 331 papers were found, of which 22 were of relevance to this study. Criteria for inclusion were for studies to be relevant to clinical nursing price, involve the study of knowledge and skills or performance feedback on practice.

1.2 Tracheal suctioning

An initial search for literature was undertaken before 2002, as this literature underpinned the development of the research instruments used with the two earlier studies (included under separate cover). This was undertaken using CINAHL (Cumulative Index of Nursing and Allied Health Literature), MEDLINE, BNI (British Nursing Index) and AHMED (Allied Health Medicine) databases. The following words were used during the search:

1. Suctioning
2. Tracheal suctioning
3. Hyperoxygenation
4. Hyperinflation
5. Normal saline instillation
6. Suction catheter
7. trache$
8. suction$
9. 1 and 3
10. 1 and 4
11. 1 and 5
12. 1and 6
13. 3 and 4

Key words were linked together using the term adjacent ("ADJ"), for example: "tracheal suctioning ADJ evidence based practice". Searches were also combined in Boolean logic with others using the word AND. A search of the Cochrane Library was also undertaken to see if any comprehensive systematic reviews of tracheal suction already existed.

The search for literature post-2002 was undertaken using EBM (Evidence Based Medicine) reviews and the Cochrane Database of Systematic Reviews. Key words used during the search were:

1. Suctioning
2. Hyperoxygenation
3. Hyperinflation
4. Normal saline instillation

5. Suction catheter
6. Negative suction pressures
7. 1 and 2
8. 1 and 3
9. 1 and 4
10. 1 and 5
11. 1and 6
12. 2 and 3

Overall, a vast range of literature was reviewed covering all aspects of the suctioning procedure. For suctioning, 62 papers were found. However, only six were of relevance to this study. Criteria for inclusion were for studies to be relevant to the suctioning procedure, involve adults as opposed to neonates and written in English. For normal saline instillation, only two studies found related to adults. For negative suction pressures, one paper was found but this did not relate to tracheal suctioning. The review has incorporated literature from both searches.

1.3 Hand searches

In addition to computerised searches, critical care journals were hand searched in order to identify potential reports of relevant trials, either in the form of articles, editorials, abstracts or letters. These journals included:

1. American Journal of Critical Care
2. Care of the Critically Ill
3. Critical Care Medicine
4. Critical Care Nurse
5. Dimensions of Critical Care Nursing
6. Heart and Lung
7. Intensive and Critical Care Nursing
8. Nursing in Critical Care
9. Physiotherapy
10. Respiratory Care

These journals were selected as they represent the majority of critical care literature and the journals where experts in the field tend to publish.

APPENDIX 9a NURSES QUESTIONNAIRE

SECTION A
DEMOGRAPHIC DETAILS

For office use only

1. Please indicate your grade

D Grade ☐

E Grade ☐

F Grade ☐

G Grade ☐

2. Age:

20-24 years ☐

25-29 years ☐

30-34 years ☐

35-39 years ☐

More than 39 years ☐

3. Gender: Female ☐ Male ☐

4. Number of years post-registration experience:

Less than 1 year ☐

1 to 2 years ☐

2 to 5 years ☐

More than 5 years ☐

5. Have you had any previous Critical Care Experience:

Yes ☐ No ☐

If yes please indicate which area

6. Please indicate any post registration courses that you have completed:

Intensive Care Course (ENB 100) ☐
Cardiac/Cardiothoracic Course (ENB 254/249) ☐

High Dependency Course (ENB A75) ☐

Other courses ☐

7. Please indicate whether you have had any education relating to suctioning:

Yes ☐ No ☐

If the answer is yes, what form did this take:

Informal bedside teaching ☐

Formal/structured teaching ☐

As part of an ENB Course ☐

As part of an Induction Course ☐

Other ☐

SECTION B

RATIONALE FOR TRACHEAL SUCTIONING

1. Which of the following may influence your decision to perform tracheal suctioning on your patient: (tick as many as appropriate).

Course breath sounds on auscultation ☐

Patient attempting to cough spontaneously ☐

Four times per shift as a matter of routine ☐

Audible or visible secretions in the airway ☐

To maintain patency and integrity of the artificial airway ☐

Suspected aspiration of gastric contents ☐

At the start of a shift as a baseline assessment ☐

To obtain a sputum specimen ☐

Patient has an ineffective cough and is unable to clear secretions ☐

2. Please comment on any additional factors that may influence this decision

SECTION C

TRACHEAL SUCTIONING

PRIOR TO SUCTIONING:

1. What information should you give the patient prior to suctioning, in order to prepare them for the procedure?

2. What actions might you consider implementing prior to suctioning in order to reduce the risk of hypoxaemia?

3. How should the above actions be implemented?

4. If hyperinflation is used in a patient receiving respiratory support, what is the recommended volume for each hyperinflation breath?

   Less than 100% of the preset tidal volume ☐

   100% to 149% of the preset tidal volume ☐

   150% of the preset tidal volume ☐

   More than 150% of the preset tidal volume ☐

5. What instances would you consider using a normal saline instillation?

6. What volume of normal saline would be recommended?

- 0ml ☐
- 1ml ☐
- 2ml ☐
- 3ml ☐
- 4ml ☐
- 5ml ☐
- More than 5ml ☐

7. What are the complications associated with normal saline instillation?

8. Please list the four important infection control measures recommended for tracheal suctioning?

SUCTIONING:

9. If a size 8 tracheostomy tube is in place, which catheter would you select:

- Size 8 ☐
- Size 10 ☐
- Size 12 ☐
- Size 14 ☐

Please give your rationale for this answer:

10. What is the recommended negative pressure for suctioning:

- Less than 50mmHg (6.6 kpa) ☐
- 50-79mHg (6.6 – 10.5 kpa) ☐
- 80-149mHg (10.6-19.8 kpa) ☐
- 150-199mmHg (20- 26.5 kpa) ☐
- More than 200mmHg (26.6 kpa) ☐
- Unsure ☐

11. How far should the catheter be inserted:

- To the end of the endotracheal tube ☐
- Until it meets resistance, then withdrawn 1cm ☐
- As far as possible ☐
- To stimulate a cough ☐
- Unsure ☐

12. When suctioning, when should negative pressure be applied:

- During insertion of catheter only ☐
- During withdrawal of catheter only ☐
- During both insertion and withdrawal of catheter ☐
- Unsure ☐

13. Negative pressure should be:

- Intermittent ☐
- Continuous ☐
- Either ☐
- Unsure ☐

14. How should the catheter be withdrawn:

- By rotation ☐
- By twisting ☐
- By upwards and downward movement ☐
- Withdrawal with no lateral movement ☐
- Unsure ☐

15. How long should each suction pass take:

- 5-9 seconds ☐
- 10-14 seconds ☐
- 15-20 seconds ☐
- 21-25 seconds ☐
- More than 25 seconds ☐
- Unsure ☐

16. How many suction passes would you make on each particular occasion:

- 1 only ☐
- 1 to 2 ☐
- 2 to 3 ☐
- More than 3 ☐

17. What factors would influence this decision?

18. During the suction pass itself, are there any additional observations you should take to ensure that patient safety is maintained?

POST SUCTIONING

19. Following tracheal suctioning, which of the following actions are recommended (tick as many as appropriate):

Listen to chest sounds and air entry ☐

Record all vital signs ☐

Assessment of the patient's colour and oxygenation ☐

Reconnection of oxygen/respiratory support therapy within 10 seconds ☐

Reconnection of oxygen/respiratory support within 30 seconds ☐

Decrease inspired oxygen to previous setting ☐

Take an arterial blood gas sample ☐

Send the catheter tip for culture ☐

Observation of sputum ☐

Measure sputum ☐

20. Are there any additional actions that you would take?

21. What are the potential hazards associated with tracheal suctioning?

Thank you for completing this questionnaire

APPENDIX 9b: **PHYSIOTHERAPIST'S QUESTIONNAIRE**

SECTION A
DEMOGRAPHIC DETAILS For office
use only

8. Please indicate your grade

Physiotherapist ☐

Senior I Physiotherapist ☐

Senior II Physiotherapist ☐

Specialist/Consultant physiotherapists ☐

9. Age:

20-24 years ☐

25-29 years ☐

30-34 years ☐

35-39 years ☐

More than 39 years ☐

10. Gender: Female ☐ Male ☐

11. Number of years post-registration experience:

Less than 1 year ☐

1 to 2 years ☐

2 to 5 years ☐

More than 5 years ☐

12. Have you had any previous Critical Care Experience:

Yes ☐ No ☐

If yes please indicate which area

13. Please indicate any post registration courses that you have completed:

14. Please indicate whether you have had any education relating to suctioning:

Yes ☐ No ☐

If the answer is yes, what form did this take:

Informal bedside teaching ☐

Formal/structured teaching ☐

As part of your physiotherapy training ☐

Other ☐

SECTION B

RATIONALE FOR TRACHEAL SUCTIONING

3. Which of the following may influence your decision to perform tracheal suctioning on your patient: (tick as many as appropriate).

Course breath sounds on auscultation ☐

Patient attempting to cough spontaneously ☐

Four times per shift as a matter of routine ☐

Audible or visible secretions in the airway ☐

To maintain patency and integrity of the artificial airway ☐

Suspected aspiration of gastric contents ☐

At the start of a shift as a baseline assessment ☐

To obtain a sputum specimen ☐

Patient has an ineffective cough and is unable to clear secretions ☐

4. Please comment on any additional factors that may influence this decision

SECTION C

TRACHEAL SUCTIONING

PRIOR TO SUCTIONING:

22. What information should you give the patient prior to suctioning, in order to prepare them for the procedure?

23. What actions might you consider implementing prior to suctioning in order to reduce the risk of hypoxaemia?

24. How should the above actions be implemented?

25. If hyperinflation is used in a patient receiving respiratory support, what is the recommended volume for each hyperinflation breath?

    Less than 100% of the preset tidal volume ☐

    100% to 149% of the preset tidal volume ☐

    150% of the preset tidal volume ☐

    More than 150% of the preset tidal volume ☐

26. What instances would you consider using a normal saline instillation?

27. What volume of normal saline would be recommended?

- 0ml ☐
- 1ml ☐
- 2ml ☐
- 3ml ☐
- 4ml ☐
- 5ml ☐
- More than 5ml ☐

28. What are the complications associated with normal saline instillation?

29. Please list the four important infection control measures recommended for tracheal suctioning?

SUCTIONING:

30. If a size 8 tracheostomy tube is in place, which catheter would you select:

- Size 8 ☐
- Size 10 ☐
- Size 12 ☐
- Size 14 ☐

Please give your rationale for this answer:

31. What is the recommended negative pressure for suctioning:

- Less than 50mmHg (6.6 kpa) ☐
- 50-79mHg (6.6 – 10.5 kpa) ☐
- 80-149mHg (10.6-19.8 kpa) ☐
- 150-199mmHg (20- 26.5 kpa) ☐
- More than 200mmHg (26.6 kpa) ☐
- Unsure ☐

32. How far should the catheter be inserted:

- To the end of the endotracheal tube ☐
- Until it meets resistance, then withdrawn 1cm ☐
- As far as possible ☐
- To stimulate a cough ☐
- Unsure ☐

33. When suctioning, when should negative pressure be applied:

- During insertion of catheter only ☐
- During withdrawal of catheter only ☐
- During both insertion and withdrawal of catheter ☐
- Unsure ☐

34. Negative pressure should be:

- Intermittent ☐
- Continuous ☐
- Either ☐
- Unsure ☐

35. How should the catheter be withdrawn:

- By rotation ☐
- By twisting ☐
- By upwards and downward movement ☐
- Withdrawal with no lateral movement ☐
- Unsure ☐

36. How long should each suction pass take:

- 5-9 seconds ☐
- 10-14 seconds ☐
- 15-20 seconds ☐
- 21-25 seconds ☐
- More than 25 seconds ☐
- Unsure ☐

37. How many suction passes would you make on each particular occasion:

- 1 only ☐
- 1 to 2 ☐
- 2 to 3 ☐
- More than 3 ☐

38. What factors would influence this decision?

39. During the suction pass itself, are there any additional observations you should take to ensure that patient safety is maintained?

POST SUCTIONING

40. Following tracheal suctioning, which of the following actions are recommended (tick as many as appropriate):

Listen to chest sounds and air entry ☐

Record all vital signs ☐

Assessment of the patient's colour and oxygenation ☐

Reconnection of oxygen/respiratory support therapy within 10 seconds ☐

Reconnection of oxygen/respiratory support within 30 seconds ☐

Decrease inspired oxygen to previous setting ☐

Take an arterial blood gas sample ☐

Send the catheter tip for culture ☐

Observation of sputum ☐

Measure sputum ☐

41. Are there any additional actions that you would take?

42. What are the potential hazards associated with tracheal suctioning?

Thank you for completing this questionnaire

APPENDIX 9c: SCORING LEGEND

SECTION AND QUESTIONS		SCORE
Section C		
Prior to suctioning		
Question 1:	Correct patient information	1
	No information	0
Question 2:	Hyperoxygenation/preoxygenation	1
	No hyper or preoxygenation	0
Question 3:	Correct method of hyperoxygenation	1
	Incorrect method	0
Question 6:	0 ml	1
	1 ml to 5 ml	0
Question 8:	Hand washing before procedure	1
	Gloves (sterile or non sterile)	1
	Aprons	1
	Protective eye wear	1
Section sub score		8
Suctioning		
Question 9:	Size 12	1
	Other responses	0
Question 10:	80-149 mmHg (10.6 – 19.8 kPa)	1
	Other responses	0
Question 12:	During withdrawal of catheter	1
	Other responses	0
Question 13:	Continuous negative pressure	1
	Other responses	0
Question 14:	Withdrawal with no lateral movement	1
	Other responses	0
Question 15:	10 to 14 seconds	1
	Other responses	0
Question 16:	Up to three suction passes	1
	More than three suction passes	0
Section subscore		7
Post suctioning		
Question 19:	Auscultation	1
	Recording vital signs	0
	Reconnection within 30 seconds	0
	Reconnection within 10 seconds	1
	Decrease inspired oxygen to previous setting	1
Question 20:	Verbal reassurance to the patient	1
	No reassurance	0
	Hand washing after the procedure	1
Section subscore		5
OVERALL QUESTIONNAIRE SCORE		20

APPENDIX 10a **OBSERVATION SCHEDULE (Nurse)**

NURSE CODE:
SUCTION NUMBER

PRIOR TO SUCTIONING **Notes**

Patient preparation	Yes				
	No				
Auscultation	Yes				
	No				
Preoxygenation:	Yes				
	No				
	Via manual rebreath bag				
	Via Tracheostomy Mask				
	Via CPAP/Nippv				
	20% above baseline				
Hyperinflation:	Yes				
	No				
Normal saline Instillation:	Yes				
	No				
	Volume: 1ml				
	2ml				
	3ml				
	4ml				
	5ml				
	More than 5ml				
Hand washing before procedure:	Yes				
	No				
Gloves:	Sterile				
	Non-sterile				
	No gloves				
Infection Control	Goggles				
	Apron				

SUCTIONING

Size of Tracheostomy Tube (French Gauge – specify)					
Size of Suction Catheter (French Gauge)	8				
	10				
	12				
	14				

Negative pressure: <50mmHg (6.6 kpa)				
50-79mmHg (6.6-10.5 kpa)				
80-149mmHg (10.6-19.8 kpa)				
150-199mmHg (20-26.5 kpa)				
>200mmHg (26.6 kpa)				

Application of negative pressure: On insertion				
Withdrawal				
Insertion & Withdrawal				

Continuous				
Intermittent				

Technique of catheter withdrawal: Rotation				
No lateral movement				
Upward and downward movements				

Duration of suction procedure: 5-9 seconds				
(from disconnection to reconnection) 10-14 seconds				
15-20 seconds				
21-25 seconds				
>25 seconds				

Number of suction passes: 1				
2				
3				
>3				

POST SUCTIONING

Reconnection of oxygen/ventilator within 10 seconds:				
Yes				
No				

Listen to breath sounds and air entry: Yes				
No				

Assessment of colour and oxygenation: Yes				
No				
Unable to assess				

Hand washing after procedure: Yes				
No				

Observation of sputum: Yes				
No				
Unable to assess				

Verbal reassurance to patient:	Yes				
	No				

Reduce FiO_2 to previous setting:	Yes				
	No				
	Not applicable				

APPENDIX 10b **OBSERVATION SCHEDULE (Physiotherapist)**

PHYSIOTHERAPY CODE:
SUCTION NUMBER

PRIOR TO SUCTIONING						Notes
Patient preparation	Yes					
	No					
Auscultation	Yes					
	No					
Preoxygenation:	Yes					
	No					
	Via manual rebreath bag					
	Via Tracheostomy Mask					
	Via CPAP/Nippv					
	20% above baseline					
Hyperinflation:	Yes					
	No					
Normal saline Instillation:	Yes					
	No					
	Volume: 1ml					
	2ml					
	3ml					
	4ml					
	5ml					
	More than 5ml					
Hand washing before procedure:	Yes					
	No					
Gloves:	Sterile					
	Non-sterile					
	No gloves					
Infection Control	Goggles					
	Apron					

SUCTIONING

Size of Tracheostomy Tube (French Gauge – specify)					
Size of Suction Catheter (French Gauge)	8				
	10				
	12				
	14				

Negative pressure:	<50mmHg (6.6 kpa)				
	50-79mmHg (6.6-10.5 kpa)				
	80-149mmHg (10.6-19.8 kpa)				
	150-199mmHg (20-26.5 kpa)				
	>200mmHg (26.6 kpa)				

Application of negative pressure:	On insertion				
	Withdrawal				
	Insertion & Withdrawal				
	Continuous				
	Intermittent				

Technique of catheter withdrawal:	Rotation				
	No lateral movement				
	Upward and downward movements				

Duration of suction procedure:	5-9 seconds				
(from disconnection to	10-14 seconds				
reconnection)	15-20 seconds				
	21-25 seconds				
	>25 seconds				

Number of suction passes:	1				
	2				
	3				
	>3				

POST SUCTIONING

Reconnection of oxygen/ventilator within 10 seconds:	Yes				
	No				

Listen to breath sounds and air entry:	Yes				
	No				

Assessment of colour and oxygenation:	Yes				
	No				
	Unable to assess				

Hand washing after procedure:	Yes				
	No				

Observation of sputum:	Yes				
	No				
	Unable to assess				

Verbal reassurance to patient:	Yes				
	No				

Reduce FiO_2 to previous setting:	Yes				
	No				
	Not applicable				

APPENDIX 10c: SCORING LEGEND

ITEM OF OBSERVED PRACTICE		SCORE
Prior to suctioning		
Prepares patient for the procedure:	Yes	1
	No	0
Hyper/preoxygenates	Yes	1
	No	0
Appropriate method used:	Yes	1
	No	0
Normal saline instillation:	Not used	1
	1 to 5 ml used	0
Hand washing before procedure:	Yes	1
	No	0
Gloves worn:	Yes	1
	No	0
Aprons worn:	Yes	1
	No	0
Protective eye wear worn:	Yes	1
	No	0
Section sub score		8
Suctioning		
Correct size of catheter used:	Yes	1
	No	0
Negative pressures 80-150 mmHg:	Yes	1
	Other pressures	0
Application of pressure:	On insertion	0
	On withdrawal	1
	On insertion and withdrawal	0
	Continuous	1
	Intermittent	0
Technique of catheter withdrawal:	No lateral movement	1
	Rotation or twisting	0
	Upwards and downwards	0
Duration of procedure:	10 to 14 seconds	1
	Less than 10 seconds	0
	More than 14 seconds	0
Number of suction passes:	Up to three	1
	More than three	0
Section sub score		7
Post suctioning		
Reconnection to oxygen within 10 seconds:	Yes	1
	No	0
Decrease oxygen to previous setting:	Yes	1
	No	0
Listen to chest sounds and air entry:	Yes	1
	No	0
Hand washing after procedure:	Yes	1
	No	0
Verbally reassure the patient:	Yes	1
	No	0
Section sub score		5
OVERALL OBSERVED PRACTICE SCORE		20

APPENDIX 11: LESSON PLAN
CONVENTION TEACHING SESSION

TOPIC: Tracheal suctioning: A review of the evidence and guidelines for practice.

DURATION: 1 hour

LEARNING OUTCOMES:

On completion of the research based teaching programme, the practitioners will be able to:

1. Demonstrate an understanding of the indications for tracheal suctioning and the decision to perform this procedure.
2. Explain how the patient should be prepared for this procedure.
3. With reference to the literature, discuss the role of hyperoxygenation and hyperinflation prior to suctioning.
4. Explore the potential benefits and hazards of normal saline instillation prior to suctioning.
5. Describe appropriate measures to minimise the risk of infection.
6. Demonstrate an understanding of the correct type and size of suction catheter and safe suctioning pressures.
7. Discuss the potential complications of tracheal suctioning.
8. Explain what assessments should be undertaken on completion of the suctioning procedure.

TIME	CONTENT	PROCESS	RESOURCES
00.00	Complete questionnaire	Activity	
00.10	Introduction to the session Assess prior experience Aims of the session	Verbal exposition	
00.15	What is tracheal suctioning? **Rationale** for suctioning Traditional versus clinical indication	Verbal exposition/ Question & Answer	Powerpoint
00.20	**Preparation** of the patient for suctioning (physical/ psychological)	Verbal exposition/ Question & Answer	Powerpoint
00.25	**Prior to suctioning:** Minimise hypoxaemia by hyperoxygenation and hyperinflation	Verbal exposition/ Debate "to bag or not to bag"	Powerpoint
00.30	Instillation of normal saline	Discussion	Powerpoint
00.35	**Suctioning:** Use of appropriate type and size of catheter, safe negative pressures and suctioning techniques Safety checks	Verbal exposition/ Question and Answer	Powerpoint
00.40	**Infection control issues:** Hand washing Gloves Protective eye wear	Verbal exposition/ Question and Answer	Powerpoint
00.45	**Post suctioning:** Reconnection of ventilation Patient and parameter checks Evaluation of effectiveness Evaluation of sputum	Verbal exposition	Powerpoint
00.50	Practical demonstration on mannequin	Practical Demonstration	Mannequin
01.00	**Session close**		

PRACTICE OUTCOMES:

On completion of the research based educational intervention the each practitioner is expected to demonstrate the ability to:

1. Identify the appropriate indications for suctioning patients under their care.
2. Prepare the patient psychologically and physically for the suctioning procedure, thus attempting to allay any fears and anxieties.
3. Hyperoxygenate the patient using 60% or 100% (or 20% above baseline in patients with COPD) either via the oxygen supply, the CPAP circuit or manual rebreath bag.
4. Use hyperinflation only if a pressure monitoring device is in the circuit.
5. Avoid the use of normal saline instillation.
6. Apply the principles of infection control by using sterile gloves during suction and wearing aprons and protective eye wear.
7. Use an appropriate type and size of suction catheter.
8. Use the correct recommended negative pressures whilst suctioning.
9. Perform a post-suctioning assessment of the patient's air entry, breath sounds, colour, oxygen saturation and sputum.
10. Reset and recheck ventilatory and oxygen parameters.

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APPENDIX 13: POWERPOINT PRESENTATION

Slide 1

TRACHEAL SUCTIONING

Tina Day
Lecturer in Critical Care Nursing
King's College London

Slide 2

Learning Outcomes

On completion of the educational programme each practitioner is expected to:

1. Demonstrate an understanding of the indications for tracheal suctioning and the decision to perform this procedure.
2. Explain how the patient should be prepared for suctioning.
3. With reference to the literature, discuss the role of hyperoxygenation and hyperinflation prior to suctioning.
4. Explore the benefits and hazards of normal saline instillation prior to suctioning.

Slide 3

Learning Outcomes cont…

5. Describe appropriate measures to minimise the risk of infection.
6. Demonstrate an understanding of the correct size and type of suction catheter and safe suctioning pressures.
7. Discuss the potential complications of tracheal suctioning.
8. Explain what assessments should be undertaken on completion of the suctioning procedure.

Slide 4

Definition

Tracheal suctioning is described as the mechanical aspiration of pulmonary secretions from a patient with an artificial airway in position (AARC, 1993).

Slide 5

Rationale for Suctioning

INDICATIONS:

- Coarse breath sounds on auscultation
- Increased airway pressures
- Audible or visible secretions
- Patient attempting to cough spontaneously
- Deteriorating ABG/SPO_2
- To stimulate a cough
- To obtain a sputum sample
- To maintain airway patency

A COMPREHENSIVE PATIENT ASSESSMENT

Slide 6

Patient Preparation

- Encourage patient participation to reduce anxiety (Fiorentini 1992).
- In unrelaxed patients with acute pain, suctioning can result in physiological and behavioural changes (Fiorentini 1992).
- Can result in choking and loss of breath (Bergbom-Engberg and Haljamae 1989).
- Care with head injured patients (Wainwright and Gould 1996).

APPROPRIATE EXPLANATION AND PAIN RELIEF IS IMPORTANT

Slide 7

Prior to Suctioning

Suctioning has been associated with hypoxaemia, dysrhythmias, hypotension, cardiac arrest and death.

- Hyperoxygenation (Glass and Grap 1995, Rogge et al 1989).
- Hyperinflation (Stone et al 1991, Singer et al 1994, Robson 1998).

Slide 8

Methods of Hyperoxygenation

- Hyperoxygenation with 100% FiO_2.
- Hyperoxygenation with 20% above baseline (Rogge et al. 1989).
- Hyperinflation volume of 100 – 150% of preset tidal volume (Wood, 1998).
- Combination of hyperinflation and hyperoxygenation.

Slide 9

Normal Saline Instillation

- An example of a widely practice intervention not supported by research
- Sputum and saline do not mix in vitro
- No evidence that they mix in vivo
- Not all saline removed. Hanley et al (1978) found only 18.7% removed
- Can reduce PaO_2 (Ackerman 1990)
- Can cause infection (Rutala et al 1984)

APPROPRIATE HUMIDIFICATION AND SYSTEMIC HYDRATION SHOULD BE USED INSTEAD OF SALINE

Slide 10

Suctioning

SIZE OF SUCTION CATHETER

- Size of suction catheter Large size catheters increase risk of trauma due to greater mucosal contact
- External diameter of the catheter should not exceed one half of the internal diameter of the tracheostomy tube (Odell 1993, Glass and Grap 1995)

RECOMMENDED FORMULA:
SIZE OF TRACHEOSTOMY TUBE – 2 x 2

Slide 11

Suctioning cont…

DEPTH OF INSERTION

- Stimulation of the vagus nerve *may cause* alterations in heart rate and rhythm
- Some suggest that if the patient is able to cough, insert the catheter just beyond the end of the tracheostomy tube (Ashurst, 1992)
- Most recommend advancing the catheter to the carina and withdraw 1 cm before applying suction (Wood 1998)

Slide 12

Suctioning cont…

NEGATIVE PRESSURES

- High levels of negative pressure have been shown to cause mucosal damage, hypoxaemia and atelectasis (Czarnik et ai 1991)
- Limiting pressures to 10.6 – 19.9 kPa (80 – 149 mmHg) is recommended.
- Suctioning should be continuous and with no lateral movement (Thelan, 1994; Glass and Grap, 1995).

Slide 13

Suctioning cont…

DURARTION OF PROCEDURE
- Most researchers recommend suctioning should take between 10 and 15 seconds to perform as longer durations are associated with hypoxaemia or mucosal damage (Boggs 1993)
- No more than three suction passes per episode is recommended (Smith 1993)

MONITORING HEART RATE, RHYTHM AND OXYGEN SATURATION IS ESSENTIAL

Slide 14

Infection Control Measures

- Hand hygiene – gloves are no substitute for this
- Gloves, sterile versus non sterile?
- Aprons
- Protective eye wear

(Little 1998, Wood 1998, Parker 1999)

Slide 15

Post Suctioning

- Reconnection to ventilation or oxygen supply within 10 seconds
- Patient assessment
- Chest auscultation
- Reset/check ventilatory parameters
- Reduce oxygen levels
- Observe and document findings

(Day 2000; 2002)

Slide 16

Potential Complications

- Discomfort (Fiorentini 1992)
- Hypoxaemia (Stone et al. 1991)
- Cardiac dysrhythmias/instability
- Trauma (Czarnik et al. 1991)
- Infection
- Cardiac arrest and death (Raymond 1995)

Slide 17

Any Questions?

APPENDIX 14 INTER-RATER RELIABILITY TESTING OF THE OBSERVATION SCHEDULE

PRIOR TO SUCTIONING:

Element of suctioning	Start of study: n = 9 Clinical setting		End of study: n = 11 Simulation setting	
	% agreement	Kappa	% agreement	Kappa
Patient preparation	100	1.0	100	n/a
Auscultation	100	1.0	100	1.0
Preoxygenation	100	n/a	100	1.0
Method of preoxygenation	100	1.0	100	1.0
Hyperinflation	100	1.0	100	n/a
Normal saline instillation	100	1.0	100	n/a
Hand washing	89	0.769	100	1.0
Gloves	100	1.0	100	n/a
Goggles	100	1.0	100	n/a
Aprons	100	n/a	100	n/a

DURING SUCTIONING:

Element of suctioning	Start of study: n =		End of study: n = 11	
	% agreement	Kappa	% agreement	Kappa
Size of tracheostomy tube	100	1.0	100	n/a
Size of suction catheter	100	1.0	100	1.0
Negative pressure applied	89	0.875	91	0.633
When applied pressure	100	n/a	100	n/a
Continuous or intermittent	100	n/a	100	n/a
Technique of removal	100	1.0	82	0.600
Duration of procedure	89	0.795	100	1.0
Number of suction passes	100	n/a	100	n/a

POST SUCTIONING:

Element of suctioning	Start of study: n =		End of study: n = 11	
	% agreement	Kappa	% agreement	Kappa
Reconnection to ventilator	100	1.0	100	n/a
Auscultation	89	0.780	100	1.0
Assessment of colour	100	1.0	100	1.0
Hand washing	100	1.0	100	1.0
Observe sputum	100	1.0	100	1.0
Verbal reassurance	89	0.727	100	1.0

APPENDIX: 15 SIMULATION SCENARIOS

Medical Patient 1 (Physiotherapist)

	SET SCENE
	75 year old female
HPC	• Admitted with an acute exacerbation of COPD • Transferred from ICU to HDU yesterday • Has had a percutaneous tracheostomy for 2 weeks
PMH	• COPD for past 5 years
SET SCENE	You have been asked to treat this patient who has a history of COPD and a chest infection. On assessment, you note that her respiratory rate has increased from 24 to 34 and her SpO_2 is 88% on 28% humidified oxygen. She has copious amounts of thick green sputum and is requiring frequent suctioning. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

Medical Patient 2 (Physiotherapist)

	SET SCENE
	62 year old male
HPC	• Transferred from community rehabilitation centre with pneumonia • Has had a trachesotomy for ten months • Tube was last changed one month ago
PMH	• Motor neurone disease for five years
SET SCENE	You have been asked to treat this patient who has been admitted to HDU with pneumonia. On assessment, his respiratory rate is 28 and his SpO_2 is 92% on 40% humidified oxygen. The nurse informs you he has required suctioning approximately every two hours. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

Surgical Patient 1 (Physiotherapist)

	SET SCENE
	67 year old male
HPC	• Admitted to SHDU from ICU • Abdominal Aortic Aneurysm repair 2 weeks ago • Has had a percutaneous tracheostomy for 10 days
PMH	• Type I Diabetes mellitus
SET SCENE	You have been asked to treat this patient who was transferred from ICU three days ago. He is self ventilating on CPAP +7.5 cms H_20 with 50% oxygen. His respiratory rate is 25 and SpO_2 94%. He has a weak cough reflex. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

Surgical Patient 2 (Physiotherapist)

	SET SCENE
	78 year old female
HPC	• Admitted to SHDU from theatre • Had facial maxillary surgery today • Had a surgical tracheostomy performed in theatre
PMH	• Asthma
SET SCENE	You have been asked to treat this patient who is in the surgical HDU. She is self ventilating on 40% oxygen. Her respiratory rate is 22 and SpO_2 94%. She is complaining of pain. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

ENT Patient 1 (Physiotherapist)

	SET SCENE
	58 year old male
HPC	• Admitted to ENT ward following laryngectomy • Has had a surgical tracheostomy for 5 days
PMH	• Previous history of cardiac failure, perioperative MI
SET SCENE	You have been asked to treat this patient who has been on the ENT ward for 5 days. He is self ventilating on 2 litres oxygen via a tracheostomy mask. His respiratory rate is 25 and SpO_2 93%. He has a strong cough reflex and you have assessed that he now requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

ENT Patient 2 (Physiotherapist)

	SET SCENE
	48 year old female
HPC	• Admitted to ENT ward following acute airway obstruction • Has had a surgical tracheostomy for 6 days
PMH	• Hysterectomy, tonsillitis and quinsy
SET SCENE	You have been asked to treat this patient who has been on the ENT ward for 6 days. She is self ventilating on 40% oxygen via a tracheostomy mask. Her respiratory rate is 19 and SpO_2 96%. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

Medical Patient 1 (Nurse)

	SET SCENE
	75 year old female
HPC	• Admitted with an acute exacerbation of COPD • Transferred from ICU to HDU yesterday • Has had a percutaneous tracheostomy for 2 weeks
PMH	• COPD for the past 5 years
SET SCENE	You have been allocated to care for this patient who has a history of COPD and a chest infection. On assessment, you note that her respiratory rate has increased from 24 to 34 and her SpO_2 is 88% on 28% humidified oxygen. She has copious amounts of thick green sputum and is requiring frequent suctioning. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

Medical Patient 2 (Nurse)

	SET SCENE
	62 year old male
HPC	• Transferred from community rehabilitation centre with pneumonia • Has had a trachesotomy for ten months • Tube was last changed one month ago
PMH	• Motor neurone disease for five years
SET SCENE	You are caring for this patient who has been admitted to HDU with pneumonia. On assessment, his respiratory rate is 28 and his SpO_2 is 92% on 40% humidified oxygen. You are informed that he has required suctioning approximately every two hours. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

Surgical Patient 1 (Nurse)

	SET SCENE
	67 year old male
HPC	• Admitted to SHDU from ICU • Abdominal Aortic Aneurysm repair 2 weeks ago • Has had a percutaneous tracheostomy for 7 days
PMH	• Type I Diabetes mellitus
SET SCENE	You are the nurse in charge of this patient who was transferred from ICU three days ago. He is self ventilating on CPAP +7.5 cms H_2O with 50% oxygen. His respiratory rate is 25 and SpO2 94%. He has a weak cough reflex. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

Surgical Patient 2 (Nurse)

	SET SCENE
	78 year old female
HPC	• Admitted to SHDU from theatre • Had facial maxillary surgery today • Had a surgical tracheostomy performed in theatre
PMH	• Asthma
SET SCENE	You are caring for this patient in the surgical HDU. She is self ventilating on 40% oxygen. Her respiratory rate is 22 and SpO2 94%. She is complaining of pain. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

ENT Patient 1 (Nurse)

	SET SCENE
	58 year old male
HPC	• Admitted to ENT ward following laryngectomy • Has had a surgical tracheostomy for 5 days
PMH	• Previous history of cardiac failure, perioperative MI
SET SCENE	You have been allocated this patient who has been on the ENT ward for 5 days. He is self ventilating on 2 litres oxygen via a tracheostomy mask. His respiratory rate is 25 and SpO2 93%. He has a strong cough reflex and you have assessed that he now requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.

ENT Patient 2 (Nurse)

	SET SCENE
	48 year old female
HPC	• Admitted to ENT ward following acute airway obstruction • Has had a surgical tracheostomy for 6 days
PMH	• Hysterectomy, tonsillitis and quinsy
SET SCENE	You are caring for this patient who has been on the ENT ward for 6 days. She is self ventilating on 40% oxygen via a tracheostomy mask. Her respiratory rate is 19 and SpO2 96%. You have assessed that the patient requires suctioning.
ACTION	Using the equipment of your choice, perform the suction procedure exactly as you would in practice.